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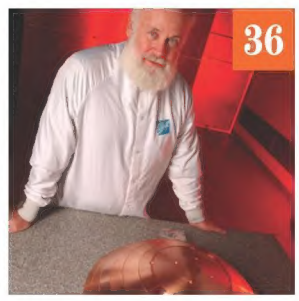
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Catch a Thrill — 2005 AIR & SPACE AIRSHOW SPECIAL


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Cover: *No, Erik Hildebrandt did not photograph this wicked Czech trainer climbing from a Russian air base but in the misty sky over Minnesota's Anoka County.*

DEPARTMENTS

We apologize that it loses 1 second every 20 million years…

The classic watch built with German precision to 1 billionth of a second?

There is a new super-accurate government device that gives you a perfect use for atomic theory. The US government has engineered the most ingenious, most accurate clock in the world, the new F-1 U.S. Atomic Clock in Boulder, Colorado. Our extraordinary new Stauer EMC^2 watch uses this clock to report the exact time from this remarkable cesium fission clock. So you are on time…all the time. This amazing clock will gain or lose only one second over a twenty million-year period. It is that accurate!

This perfectly tuned technological invention is now available for UNDER $100. And you'll never have to set this watch…the hands set themselves. Just push one of the buttons and you are synchronized with the F-1 and the hands of the watch move to the exact time position. The Stauer EMC^2 exceeds the accuracy of any Swiss luxury automatic so you can be more accurate and keep most of your money in your wallet… not on your wrist.

There are some unattractive plastic digital atomic watches on the market, but when our German movement maker made it possible for us to break the $100 price barrier with a beautiful, classically styled stainless steel analog watch, we were truly excited.

The EMC^2 features precise atomic time with an automatic Standard time and Daylight Saving Time adjustment. It will adjust for leap years and even leap seconds! A breakthrough in technology at a breakthrough price.

The large numeric markers are luminescent and extremely easy to read so the watch is perfect for low light situation. The EMC^2 is water-resistant to 5 atms as well. The small readout shows you the date and has a digital second counter. This watch is rugged enough to take to the gym but handsome enough to wear to the boardroom or out to dinner. The designers built this watch for those who prefer their watches to be practical and sharp-looking rather than overrated and overpriced.

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This watch is not available in stores and it comes with our 30 day money-back guarantee. If you're not completely satisfied with the accuracy, simply return the watch for the full purchase price.

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With these bold words—"I would found an institution where any person can find instruction in any study"—Ezra Cornell established his namesake Ivy League university 140 years ago. Inspired by his ideal of universal access and bolstered by modern technology, the National Air and Space Museum's Education Division has created programs that do old Ezra one better. Our supplements, tailored to all the age groups of our visitors and aligned with national educational standards, can be accessed by any person from any location at any time. In this way, the Education Division supports the Museum's simple motto: "Commemorate, Educate and Inspire."

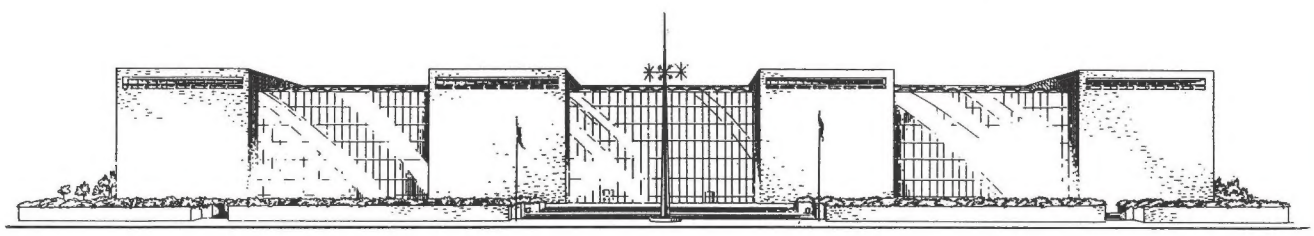
Our Education Division operates the Museum's docent program, manages the hands-on How Things Fly gallery, provides interpretive support to exhibits, and conducts educational activities for visiting school groups. In addition, the staff manages the Discovery Stations, a series of portable interpretation centers that encourage learning through observation, discussion, and hands-on activities.We are now adopting technology to expand our reach beyond the Museum's walls. Information tailored for teachers and a variety of educational materials are presently available through *www.nasm.si.edu/education*—the NASM Web site. Our Education Division also extends its reach by means of partnerships with other organizations. One example: ProjectView, a live, interactive distance learning program using videoconferencing to reach middle schools in the Schenectady, New York area, showcasing the artifacts and message of the Wright Brothers & The Invention of the Aerial Age gallery.

We teamed with Indiana's Ball State University, the Apple Learning Interchange, Best Buy, and others to provide two one-hour Electronic Field Trips for students across America. These events were broadcast/Webcast live to a potential audience of millions, and their Web sites contain background material from the EFTs as well as information for teachers on how the activities align with educational standards. The sites also include an archived version of the original broadcast.

We host lectures on aviation and space topics throughout the year, with an annual aggregate audience of several thousand, and provide supplemental activities and materials. We use our EFT partnership with Apple Learning Interchange to offer cyber-visitors—anyone, any place (with a suitable computer connection), any time—access to these lectures. Those who attended can revisit their experience, and those who could not attend can participate from afar, in real time, after the fact, or both.

We have another budding partnership with the Fairfax County, Virginia public schools. FCPS operates an outstanding studio and broadcast facility and has an extensive computer network to disseminate programs, so we are exploring ways to provide content they can distribute. We already enjoy the benefits of collaboration with their neighboring counterpart in Loudoun County and look forward to expanded student access.

—J.R. Dailey is the director of the National Air and Space Museum.



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Air & Space/Smithsonian (ISSN 0886-2257) is published bimonthly by Smithsonian Business Ventures, MRC 951, P.O. Box 37012, Washington, DC 20013. Editorial offices: MRC 951, P.O. Box 37012, Washington, DC 20013. Circulation and advertising offices: 420 Lexington Ave., New York, NY 10170. Canadian publication agreement no. 40039324. Canadian return address: 7496 Bath Road, Unit 2, Mississauga, ON L4T 1L2.
Subscription Prices: U.S. and possessions: $24 a year payable in U.S. funds. Canada and all other countries: add $6.00 (U.S. funds) per year. Eighty-five percent of dues is designated for magazine subscription. Current issue price: $3.99 (U.S. funds). Back issue price: $7.00 (U.S. funds). Periodical postage paid at Washington, DC, and additional mailing offices.
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LETTERS

The Low-Tech/High-Tech U-2

As a flight surgeon assigned to the Ninth Wing at Beale Air Force Base in California, I had the privilege of working with, taking care of, and playing with the pilots and maintenance and support personnel of the U-2 program between 1989 and 1993, so "The U-Deuce" (Feb./Mar. 2005) was a walk down memory lane for me.

I enjoyed reading your description of the multiple sensor systems. However, your concentration on the high-tech sensors belied how basic this wonderfully capable aircraft's design really is. From the pilot's perspective, the U-2 is a straightforward airplane with cable-connected control surfaces, a large engine, and a very-high-aspect-ratio wing. Lightly loaded, she'll climb like a homesick angel. It is the only tail-dragger in the U.S. Air Force inventory and, though it has a bicycle gear, is flown much like any other conventional-gear airplane.

Ideally, landings are made at a full stall onto the runway. The pilot cannot see the runway in the flare due to both the nose-high attitude and the pressure suit that he or she wears. During landing, a high-performance car is driven by a second U-2 pilot behind the airplane down the runway in order to give the pilot his height above the runway until touchdown. At one location a 7-series BMW was used. The airplane is also the only powered aircraft in the Air Force with a yaw string, a simple string on the outside of the canopy that indicates if the aircraft is trimmed properly.

Scott Tweten
San Anselmo, California

In the mid-1960s, as part of a team of eight engineers, I worked on a proposal for the technology that set in motion the initial change in the U-2's primary function. The proposal was to install in the U-2's brand-new wing pods a payload identical to my company's very successful Elint satellite. A payload designed for use in space had never been installed in a U-2 before. The proposal was accepted, and the contract was awarded to Lockheed's Skunk Works facility in Palmdale, California. Some years later I was somewhat amazed to find a plastic model of the U-2R with the outboard pods. When I was working on the project, that was extremely classified information!

Alex Morton
Issaquah, Washington

"The U-Deuce" should have been subtitled "One of the Most Useless U.S. Warplanes." The capabilities of the U-2 and all the other aircraft mentioned in the article would be great if we had another conventional war, such as World War II. But they are useless for the war in Iraq. They cannot detect roadside bombs, bomb-carrying vehicles, the suicide bomber who casually walks into a military compound, or the Iraqi teenager carrying a missile. What a waste of technology and money.

Arthur C. Fox
Wallkill, New York

I remember the first time I saw the U-2. I was stationed at Ramey Air Force Base in Puerto Rico with the 72nd Bomb Wing when a detachment of U-2s arrived on the base; I believe it was in 1958. At the time the U-2 was based at Laughlin Air Force Base in Del Rio, Texas, and the aircraft were not painted but had natural aluminum skin. We were told that the detachment was doing high-altitude atmospheric research, but we thought otherwise.

Every morning at 07:00, one aircraft would take off and not return until late afternoon. When the aircraft landed we were treated to a show: the pilots trying to taxi back to the hangar without the outrigger wheels. A couple of times one would make it all the way, but most times they lost it when turning off the runway. A Ford station wagon carrying the crew chief and the outrigger wheels followed the aircraft, and when a wingtip touched the ground, the aircraft would stop and the outriggers would be plugged into the wing. The crew chief would then jump on the wing and ride back to the hangar.

Master Sgt. Alfred Babinsky
U.S. Air Force (ret.)
Gig Harbor, Washington

Ancestor of the Grasshopper

The photograph of the Slingsby Grasshopper ("Vintage Charmers," Feb./Mar. 2005) looks very much like a rudimentary glider Germans used in the 1930s to teach the teenage Hitler Youth the principles of flying.

Hans-J. Pfeiffer
Peoria, Illinois

Editors' reply: The Slingsby Grasshopper is indeed descended from a 1926 German training glider, which in turn evolved from an even earlier design.

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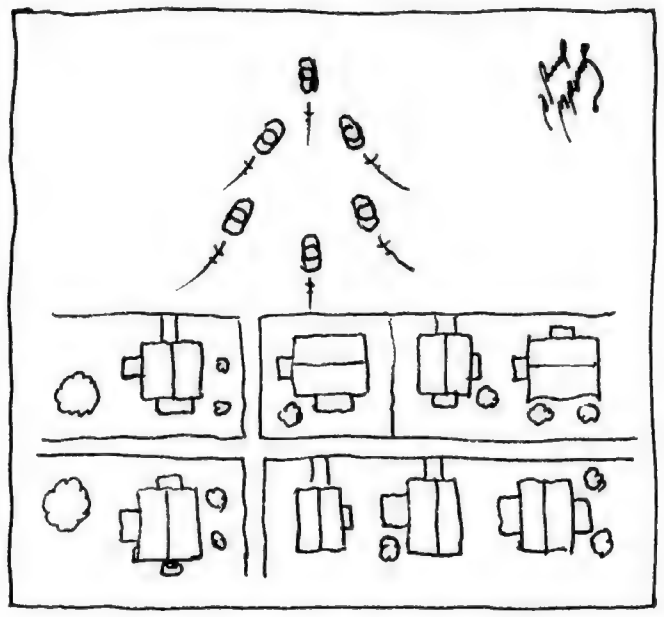
How to Waterproof a Jet Engine

So few Temco TT-1 Pintos were made, I was amazed to see that one had survived ("Pony Power," Restoration, Feb./Mar. 2005). I grew up near Saufley field in Florida, where the Navy was testing them. They would scream over our house, trying to gain altitude with their obviously anemic engines.

One footnote: It rains a lot in Florida, and that can leave fairly sizeable puddles on the runways. The Navy soon found that when the TT-1, with its tiny powerplant and its intakes placed on the lower sides of the fuselage, hit the right-size puddle at the right speed, the water that splashed up from the nose wheel would put the fire out. The fix was a fender that covered the upper half of the nose wheel. As far as I know, the TT-1 has been the only jet with a fender.

Sam Cheatham
Golden, Colorado

Editors' reply: Numerous jets have devices to control the water sprayed up and out by landing gear on takeoff and landing. Flight testing to obtain certification includes high-speed runs through water to determine the spray pattern the wheels produce.



The Blue Angels leave for work.

Elephant Memories

I feel compelled to offer a few clarifications about the incident described in "Rogue Elephants" (Above & Beyond, Feb./Mar. 2005). I was the Red Forces Commander for Amalgam Warrior '88, the exercise that the article describes. The primary purpose of the exercise was to offer a live-fly environment in which to exercise the battle management capabilities of the Alaska region of NORAD (the North American Aerospace Defense Command). With roughly 70 aircraft in each force (Blue and Red), we designed a graduated threat level throughout the exercise, beginning with a warmup day and concluding with a large force-on-force scenario. The scenarios were planned well in advance, and the planning involved representatives of all participating units. No unit commander made an autonomous decision to violate a scenario or the rules of engagement.

Colonel Jim Richards maintained appropriate discipline and acted in line with the exercise scenario when he instructed his crews to plan and present a thoroughly aggressive threat for the final exercise day. If the crews of the 668th Bomb Squadron did not know of the scenario, I can only conclude that Colonel Richards kept the information from them in order to challenge them.

As for the statement that the Red Force did not understand the capabilities of the B-52, I flew the B-52 several years before my assignment as a pilot in the 21st Tactical Fighter Wing at Elmendorf Air Force Base in Alaska. I was intimately aware of the aircraft's capabilities and, from the early stages of exercise planning, intended to fully employ those capabilities at the appropriate time. The bomber crews did not disappoint me. The resultant challenge to the battle management system was valuable in shaping future training and exercise programs, which in turn improved NORAD's readiness.

Lt. Col. Ed Whitt
U.S. Air Force (ret.)
Bryan, Texas

"Rogue Elephants" reminded me of a similar mission some 42 years ago. I was the electronic warfare officer on a B-52G assigned to the 340th Bomb Squadron, 97th Bombardment Wing, at Blytheville Air Force Base in Arkansas. My crew was among those who flew a mission called Sky Shield. The mission started above the Arctic Circle, penetrated the Distant Early Warning Line (DEW), and flew south through Canada to the United States. We were to imitate Soviet bombers attacking the United States. We had rules similar to what Mr. Novak experienced. We weren't allowed to use electronic countermeasures or vary from our assigned course, and low level wasn't an option.

By the time we were 30 minutes into our penetration, we had been "shot down" by several Canadian CF-100s. Once across the U.S. border we were attacked by U.S. F-86s. The whole mission took only nine hours. I remember all of us thinking that the mission proved nothing. We did not demonstrate any of our Tactical Doctrine training, and the fighters certainly faced no challenge. The only advantage I saw to the mission was that we got nine hours of flying time.

One thing in "Rogue Elephants" made me proud: The demonstration was done by a Griffiss Air Force Base crew. In the 1970s, I, like the author, was stationed with the 668th Bomb Squadron, 416th Bombardment Wing, at Griffiss. Thanks, James Novak, for putting us in the history books.

Maj. Robert M. Saxton
U.S. Air Force (ret.)
Katy, Texas

Editors' note: For more on Sky Shield, see "This Is Only a Test" (Feb./Mar. 2002).

We Were There Too

"Splashdown" (Feb./Mar. 2005) made no mention of the Air Force personnel involved in the space capsule rescues. I personally flew and participated in at least five Gemini flights, and in two of these, the 76th Air Rescue Squadron's HC-97G Stratofreighter was the first on the scene of the splashdown.

Aubry H. Johnson
Santa Maria, California

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All letters selected for publication are edited. We regret that we cannot respond to every letter.

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— General John R. Dailey, USMC (Ret.), and his wife Mimi
In front of the Museum's Boeing F4B-4. Dailey's father and his inspiration, USMC Brig. Gen. Frank Dailey, flew the very plane that's now in the Museum's collection.

PHOTO: [illegible] RUSSO

"I want to give visitors access to the entire Museum collection...."

"I hope to inspire future generations by making the legacy of the Wright brothers accessible to them. The thousands of artifacts at both the flagship building on the National Mall and the new Udvar-Hazy Center show the history, science, and technology of flight in dynamic, meaningful ways." —General John R. Dailey

To celebrate the Centennial of Flight, the National Air and Space Museum opened its companion facility, the Steven F. Udvar-Hazy Center, on December 15, 2003. For museum director John R. "Jack" Dailey, the opening of this facility is the culmination of a dream and of many years of effort.

Dailey, a highly decorated pilot and a leader in the Marine Corps, at NASA, and now at the National Air and Space Museum, is leading the expansion of the most visited museum in the world. To commemorate the opening of the Udvar-Hazy Center and the Centennial of Flight, Dailey and his wife Mimi have made the National Air and Space Museum a beneficiary of their will, making them members of the *Smithsonian Legacy Society*.

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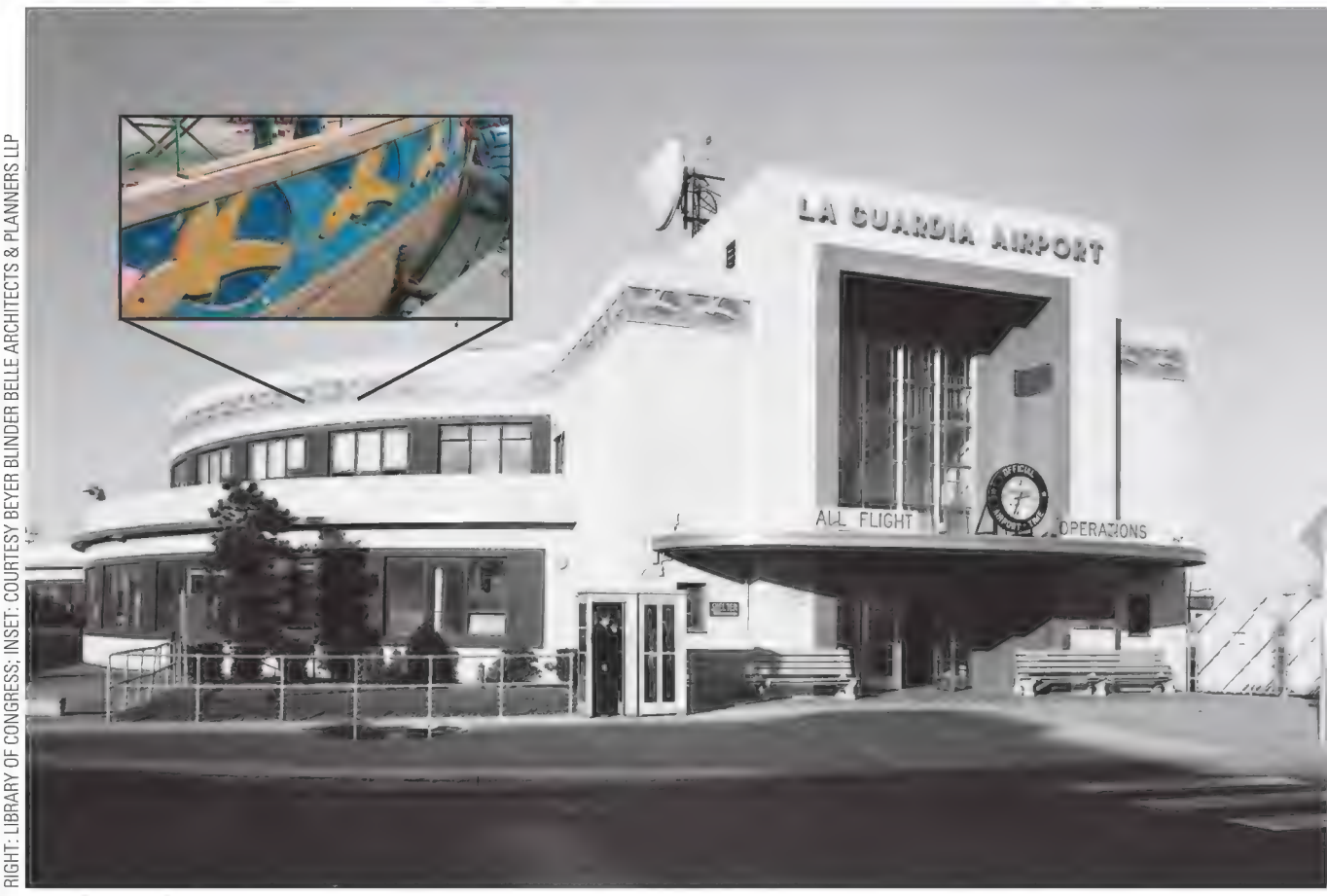


RIGHT: LIBRARY OF CONGRESS; INSET: COURTESY BEYER BLINDER BELLE ARCHITECTS & PLANNERS LLP

Restored to its former glory, including the flying fish frieze (inset), the Marine Air Terminal at LaGuardia Airport lacks only the fleet of seaplanes that once served it.

The New York metropolitan area is tough on historic buildings, and nothing illustrates that better than LaGuardia Airport. Built in the late 1930s by Franklin Roosevelt's Works Progress Administration, LaGuardia soon became the place where Depression-era citizens paid a dime to gain entrance to the observation deck and watch shiny airliners ferry the wealthy to and fro. Back then the airport had two terminals: the Land Air Terminal, which handled domestic-route airliners, and the Marine Air Terminal, which supported Pan Am's seaplanes as they spanned the more or less airport-less globe. The Clippers, as they were called, would land in the bay behind the Marine Air Terminal and be towed to the terminal, where passengers would board or disembark.

By the 1960s the magnificent Art Deco Land Air Terminal was surrounded and absorbed by the ugly but practical Central Terminal Building. Though seaplane service died out after World War II, the elegant Marine Air Terminal somehow survived and eventually became the base for shuttle service to and from Boston and Washington. But time wasn't kind. Inside the two-tier circular building, a 235-foot-long WPA mural, "Flight," painted by James Brooks and illustrating the history of aviation, was covered by a coat of dull paint during the McCarthy era because of an alleged socialist theme. The building's facade suffered a more benign form of neglect.

COURTESY RICHARD SCARPITTA/ FORD UNIVERSITY ARCHIVES

Detail from the interior mural "Flight."

"It was in poor condition," says Richard Southwick, a partner in the architecture firm Beyer Blinder Belle. "Much of the brick was delaminating, and the anchoring of the masonry facade was falling away." In the late 1980s, workers rehabilitated the interior, including ticket counters and the pink Tennessee marble floor. Brooks himself restored his mural. And just recently Beyer Blinder Belle completed a two-year, $6.5 million project funded by the Port Authority of New York and New Jersey to restore the exterior. Workers removed and cleaned some 2,000 tiles from a polychrome terra cotta frieze of flying fish and restored the chocolate-colored accent tiles surrounding the windows and entrance. "All of it had been painted over at one time," Southwick explains. The company also replaced some of the facade's anchoring rods, rebuilt the brick parapets, and even replaced a window installed 20 years ago that didn't match the rest of the building. "In a way it was a complete restoration, all the way up to the top of the skylight," Southwick adds.

But can you still fly seaplanes here? "I would love to see that," Southwick says. "However, [today] the airport is very different."

—Phil Scott

Great Expectations

The business plan of of El Segundo, California's Space Exploration Technologies, or SpaceX, owned by Internet entrepreneur Elon Musk, is to sell cargo space on rockets for about one-third the current going rate for U.S. space launches. The company's debut mission, scheduled for this year, is to place an experimental communications satellite, TacSat-1, into polar orbit for the Department of Defense, which is paying $6 million for the launch. A similar mission aboard Orbital Sciences' Pegasus booster, which can carry about the same weight as SpaceX's Falcon 1, costs about $25 million.

The Falcon's first flight will be launched from Vandenberg Air Force Base in California, where SpaceX took over an abandoned Atlas launch pad. Now the company is looking to do the same at Complex 36, a launch facility at Florida's Cape Canaveral Air Force Station where the Atlas family of rockets operated for 40 years. The 145th and final Atlas rocket blasted off from Pad 36B on February 3. (Pad 36A launched its 63rd and final Atlas mission last August.) Lockheed Martin, which builds the Atlas booster, has moved its operations to Cape Canaveral's Complex 41 and phased out all varieties

of its Atlas rockets except for the heavy-lift Atlas 5.

"The [U.S. Air Force] 45th Space Wing is in discussions with SpaceX," says Air Force spokesman Ken Warren. "They would like to lease both pads, 36A and 36B, for the Falcon 1 and Falcon 5 rockets." SpaceX currently has submitted its vehicles for safety and environmental reviews, a process that could take six to 12 months to complete, Warren says.

Complex 36 is especially well-suited for the Falcon fleet, as both the Atlas and the Falcon have motors that burn highly refined kerosene and liquid oxygen. About the only Complex 36 amenities SpaceX cannot use are the Atlas launch towers. Falcon boosters, which are nearly ready for flight by the time they leave the manufacturing facility, undergo final launch preparations in a horizontal position and are rolled to the launch pad on a flatbed truck. For liftoff, the truck hoists the rocket and its built-on umbilical tower to a vertical position.

In addition to the California and Florida sites, SpaceX plans to launch from the Ronald Reagan Ballistic Missile Defense Test Site on the Marshall Islands' Kwajalein Atoll in the western Pacific Ocean. Falcon rockets need to be launched over open water because their first stages (including the engines) will parachute into the ocean and be recovered, refurbished, and reused on future flights.

SpaceX has reservations for three more missions after the Falcon's debut flight: another for the military, one for the government of Malaysia, and one in 2006 in which the company's medium-lift Falcon 5 booster will place a prototype inflatable space hotel in orbit for the startup commercial space firm Bigelow Aerospace. Musk estimates his rockets could fly from Florida as early as 2007, probably a little early for SpaceX's eventual payload: passengers.

—Irene Mona Klotz

Shoes for a Lifetime

Not all the post-*Columbia* safety upgrades developed for the shuttles' return to flight focus on external tank redesigns, techniques to repair the thermal protection system, and emergency evacuation plans. Some gear is as down-to-Earth as some new shoes—make that 456 shoes, plus a dozen or so spares.

Since the Apollo program, NASA has

MARK WAGNER/ AVIATION-IMAGES.COM

The Debut of the Superjumbo

An exuberant crowd of 5,000 attended the seven rollout of the Airbus A380 in Toulouse, France, last January 18. Like most aircraft rollouts, the affair was a pageant, music, dry ice, and dancers helped to introduce the double-decker jet, which has a price tag of about $257 million. To date, Airbus has orders from 13 countries for 149 aircraft. Configured with first, business, and economy classes, the A380 will seat 555, 139 more than the typical Boeing 747 configuration. And like most new aircraft projects, the A380 is over budget, —in this case by $1.4 billion. However, Airbus believes that by 2008 the A380 will be enormously profitable.

TYLER J. CLEMENTS/US NAVY

Not Coming Soon to a Carrier Near You

Last summer, an e-rumor spread throughout cyberspace about a radical new aircraft. "Northrop has delivered a prototype for the new F/A-37," the posters claimed. "It's a Mach 3.5, supercruise stealth fighter/bomber/interceptor with a very wide combat radius." Attached were photographs, alleged to be of the first flight item undergoing "catapult fit checks," which lent cursory visual credibility to the story.

The new airplane was phenomenal in its versatility. Apparently a development of the forward-swing-wing Switchblade design patented in 1999 by Northrop Grumman, the fighter-bomber was purported to be faster than Lockheed's Blackbird, yet could be slowed enough to land on a carrier. At in-between speeds, a forward-swept mid-range wing (think X-29) would enable exceptional maneuverability.

Despite the veneer of authenticity, the photographs showed details that were puzzling. The airplane was chained to the deck of the aircraft carrier from which it was about to be launched, for example, and the canopy appeared to be assembled with pop rivets.

Researchers traced the origin of the photographs to the Navy Eye on the Fleet Web site, where the original images by Photographer's Mate 3rd Class Tyler J. Clements had been posted, along with the explanation that they had been taken aboard the aircraft carrier USS *Abraham Lincoln* during filming for an upcoming Sony Pictures movie titled *Stealth*, slated to open on August 9.

To this day, new "stealth sighting" postings continue, despite numerous efforts to debunk the Internet urban legend. Then again, it all may have been part of a slick marketing scheme by Sony Pictures.

—Larry Lowe

relied on a pair of flatbed tractors to shoulder the 11-million-pound shuttle stack and launch platform load from the assembly hangar to the launch pad. The crawler-transporters, which were modified for space shuttle use after the lunar exploration program folded, still have much of their original equipment, including—until recently—a collection of steel shoes.

Taking advantage of the shuttles' downtime following the 2003 *Columbia* accident, Kennedy Space Center personnel thoroughly inspected all ground support equipment. Technicians used borescopes to peer inside the 7.5- by 1.5-foot crawler shoes and found a mess.

"There were cracks and other evidence of stress fatigue," says Robert Rokobauer, a transporter system engineer with shuttle prime contractor United Space Alliance and a 33-year space center veteran. "We also discovered that the original manufacturing process was somewhat defective, with a lot of porosity in the center of the shoes that helped propagate the cracks from the inside. It's surprising it lasted for 40 years with the service life it had."

Engineers began a search for a suitable manufacturer and ended up hiring ME Global Manufacturing of Duluth, Minnesota, to forge the new shoes. The firm produces similar products for the mining industry. ME Global worked with NASA contractors to slightly modify the chemistry and shape of the shoe to eliminate air pockets that were forming as the metal was cast.

NASA's crawlers have four double-track wheels, with 57 steel shoes attached to each belt. The shoes, each of which weighs 2,150 pounds, are linked by 30-inch-long, 3.25-inch-diameter steel pins. To remove the old shoes, engineers disconnected one of the tread belts and moved the crawler so that it would walk off the tread. Once the treads were removed, a crane lifted them out of the way. Technicians then laid out a line of new shoes, pinned them together, and rolled the crawler back over the belt so it could wrap itself around the crawler wheel.

KSC/NASA

Kennedy Space Center technicians discovered that the crawler-transporters that bring the shuttles to the launch pad needed new shoes.

Just getting the shoes to the space center was an ordeal. Truckers could transport only 22 shoes at a time; a heavier load might have damaged the highways. NASA also decided to upgrade the crawlers' ventilation systems, refurbish the gears and rollers that drive the crawlers' track belts, replace wiring in the motor control systems, and install new driver cabs, mufflers, and radiators. The overhaul cost NASA $11 million, says crawler transporter manager Ray Trapp.

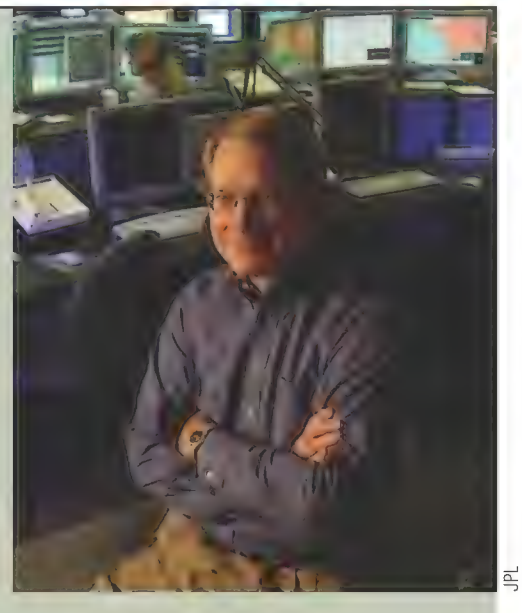
In February, engineers test-drove the newly re-shoed crawler transporter that will be used to haul *Discovery* to the launch pad for the first post-*Columbia* mission, scheduled for mid-May. The crawler carried an empty launch platform to the pad and back, moving over rock as well as smooth surfaces. Inspections showed no cracks, says Trapp. With the upgrade, the crawlers' new shoes should be good for another 100 years—although the shuttles are scheduled to fly for only another five years.

—Irene Mona Klotz

PEOPLE AT WORK

The Best Jobs in Aerospace

Donald K. Yeomans
Manager, NASA's Near-Earth Object Program Office
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



JPL

Mountain-size nomads of the solar system pay heed to no calendar, a simple truth that I was reminded of last Christmas Eve, when my team and I were tracking a 1,000-foot-long, 49-million-ton space rock that, at one point, seemed to have a 1-in-40 chance of smacking into Earth. The fact that our families were at home enjoying the spirit of the season, or that the potential catastrophic event would occur no earlier than 2029, was of little consolation. A lot of coffee, orbit crunching, and urgent requests for additional observations later, we had an improved trajectory that ruled out an Earth impact for 2029. Just another day for the Jet Propulsion Laboratory's Near-Earth Object Program Office.

The NEO program office is assigned to discover, monitor, and figure out just what is up there that could end up in our back yard. With the help of JPL's sophisticated SENTRY computer system, the motions of all known near-Earth objects are monitored 24/7 for future close-to-Earth approaches. NASA has discovered, plotted, and tracked everything from asteroids, comets, and even the occasional itinerant space hardware, like a stage from an Apollo moon rocket. To date, we have logged over 3,100 near-Earth objects, and the number grows daily. While no space objects we have tracked are headed thisaway, we are constantly looking. That's what we do.

Harder Than a Heathkit

As a kid, John Pultorak built space capsules out of cardboard. But now that he's a 51-year-old Lockheed Martin software engineer, he's left such childish pursuits behind. His latest project was scratch-building a functional replica of the Apollo Guidance Computer, which helped take NASA to the moon.

"I was interested in the AGC because it was the world's first integrated-circuit computer," Pultorak says. "And I wanted to do something that was really in-your-face, that made you say 'Oh my gosh! I can't believe you did that!' "

COURTESY JOHN PULTORAK

Retro-geek: John Pultorak built an Apollo Guidance Computer from scratch.

Mission accomplished. After a four-year labor of love tinged with admirably geekish obsession, Pultorak recently unveiled a 70-pound colossus—five feet high, three feet wide, and four inches deep—in the basement of his home near Denver. "If you're a nerd like me," he says, "it's pretty cool."

Imagine 363 lights, 15,000 hand-made connections, and two-thirds of a mile of exposed wiring so fine it looks like angel-hair pasta. Oh, and Pultorak built it all himself—hardware, software, and a pair of simulators created to test them along the way, using largely obsolete materials. "When I finally got finished," he says, "I was almost afraid to plug it in."

Pultorak's project was born of humble beginnings. After remodeling his basement, he found he still had creative energy to burn. And since he was a child of the Space Age with several homebuilt computers already under his belt, he gravitated naturally to the AGC project.

Developed at the Massachusetts Institute of Technology and built by Raytheon, the Apollo Guidance Computer was designed to serve as the primary on-board navigation aid in NASA's lunar program. It would be especially critical, engineers thought, when astronauts lost communication with Earth, either because of an equipment failure or because their spacecraft was behind the moon.

By modern standards, the AGC is ridiculously primitive, with 1/1,000 of the internal memory of a personal computer and running at maybe 1/2,000 of the speed. But Block I computers flew on two unmanned missions. (Another was lost in the fatal Apollo 1 command module fire of 1967.) And Block II AGCs were in the command and lunar modules on all flights to the moon.

Despite the historical significance of the computers—they jump-started the development of integrated circuitry—Pultorak couldn't find much technical information about their construction. But he eventually pieced together enough documentation to puzzle out what made the Block I machine tick.

Pultorak was "elated" when he got the AGC to work, but now the novelty has worn off. "You can't do a damned thing with it," he admits. "To tell you the truth, I never really wanted [to own] this thing. I just wanted to build it."

—Preston Lerner

IT SWIMS WITH THE FISHES

LEFT:: NOAA/HURL; BELOW: US NAVY

The nose of the Marshall Mars, *inverted (left), and the whole shebang in its salad days (below).*

Another Mars Mission

Last December, U.S. environmental research groups examined and photographed the remains of a transport that caught fire and sank (with no loss of life) off the Hawaiian island of Oahu in 1950. The U.S. Navy's Martin JRM-1 *Marshall Mars*, a sister ship to the *Philippine Mars* and *Hawaii Mars*, which have been reincarnated as Canadian fire tankers (Martin built only five 170A Mars), is resting in pieces on the sea-floor graveyard, surrounded by the bones of a Japanese mini-submarine and other aircraft from the 1920s on.

Researchers from the National Oceanic and Atmospheric Administration, the University of Hawaii, and the National Park Service were conducting surveys to determine how large an area needs to be protected as a repository of cultural relics. Last August, when researchers discovered the nose and keel of what appeared to be a seaplane, Terry Kerby of the Hawaii Undersea Research Laboratory, piloting a submersible, maneuvered close to the nose and was able to read "Marshall" painted on it. Kerby later was shown the image at right above and in December returned to the site. "We maneuvered near aircraft debris that was bent and corroded aluminum with traces of dark blue paint," he says. "Then we came upon a huge engine. Further on, we saw propellers that were attached to a second huge engine that was still on the wing. And then we discovered a third engine. We knew we'd found the main body of *Marshall Mars*."

UPDATE

Boeing Pulls the Plug

Boeing announced last January that after building the eighteen 717s on order for AirTran Airways, Midwest Airlines, and Turkmenistan Airlines, it will end production of its short-haul airliner and shut down the Long Beach, California plant in mid-2006 ("Vital Signs," Dec. 2004/Jan. 2005). The 717, originally designated MD-95, was the only McDonnell Douglas commercial program that Boeing continued when it took over in 1998.

German Tales From the Russian Front

Günther Rall, a decorated fighter ace during World War II (right), gave a lecture last October at the Udvar-Hazy Center (above, left). Roy Sutherland of 21st Century Toys painted a model of a Messerschmitt Bf 109 in Rall's squadron markings and had Rall sign it. The model was later auctioned for the National Air and Space Society.

OPPOSITE: MARK AVINO; LEFT: JOSEPH SUAREZ COLLECTION (SI NEG. #96-15262)

In 1944, an American pilot blew Günther Rall's thumb off. Rall was a renowned fighter pilot in the German air force who had scored more than 200 kills and flown several hundred missions on nearly every major European front in World War II. The Allies, deep in enemy territory to attack factories, had amassed 800 B-17 Flying Fortresses and B-24 Liberators, both long-range bombers, and 1,200 fighters, mostly P-47s, to break through a greatly weakened Luftwaffe defense of just a few hundred airplanes.

"I'm sure the earth below must have been trembling because the thunder from those thousands of engines was tremendous," Rall recalled in his biography, *Günther Rall: A Memoir*, by Jill Amadio. Rall signed copies of the book at a lecture he gave last October at the Smithsonian Institution's Steven F. Udvar-Hazy Center at Dulles airport in northern Virginia. (The lecture was sponsored by the National Air and Space Society; see *www.nasm.si.edu/membership*.) In the book, Rall goes on to describe what happened when he came face to face with four P-47s. He knew his Messerschmitt Bf 109 could not outdive the U.S. airplanes, but eventually, he had to descend. As he spiraled down, they shot up his engine, cooling system, and hand, forcing him to bail out. He descended over a field, and his parachute got caught in a tree.

A German farmer, unsure which nationality of airman had fallen from the ferocious battle overhead, came at him with a pitchfork. "Who are you?" the farmer demanded.

"Major Günther Rall, Luftwaffe," Rall replied. "The farmer and his helpers knew me right away," he told the audience. "I was still in agony but very happy."

Rall had to bail out eight times during the war, but he always seemed to fall in the right place at the right time. The audience laughed when Rall gave a brisk summary of what he'd learned from being shot out of the sky yet again: "Two thumbs are unnecessary."

Many of those who came to hear Rall speak, like Joe Cain of Austin, Texas, had parents who served on the side of the Allies. But the members of the audience gave no sign that they were judging him. "This is just about the engineering and flight and heroics," said Cain. "There's no sides now."

On one level Cain is right. As Rall told stories of surviving 30-below-zero temperatures on the Russian front, listeners couldn't help being awed by the Germans' resilience. "We put fires under our engines," Rall said. "No such thing as safety regulations."

Sitting in a soft chair on stage, Rall described those days in 1941 and '42 on the Eastern front, when he served as commander of the Luftwaffe's Eighth Squadron. In a matter-of-fact tone, he discussed the men he took out of the sky and the weaknesses of various Russian aircraft, especially the Lavochkin fighters (he downed 183 of them). "The Russians had old equipment and no formations, but they had a tremendous fighting spirit," said Rall. "I have to confess to that." The Germans destroyed 2,000 Russian airplanes in 1941 alone.

But as one flips through Rall's memoir, complete with photographs of the swastika-embossed Knight's Cross that he won for his 65th combat kill, it's hard not to recoil at the sight of these Nazi symbols and the atrocities they

bring to mind. Consequently, when Rall writes about the losses in his squadron, they don't seem as awful as the deaths of the Allied aviators.

Wearing a tweed jacket and sitting with slightly stooped shoulders, Rall, in person, seemed a far more sympathetic figure than he appears on the page. The audience listened quietly as he described day-to-day life on the Russian front, cut off from reliable communication, starving, and watching comrades freeze to death. At one point he had to land his Bf 109 (an example of which is on display at the National Air and Space Museum) with the gear up and broke his back. It took him nine months to recover. When he returned to the Eastern front in 1942, he discovered that nearly all the members of his squadron had died. "They were gone," he said. "Very hard. Very bad."

In his biography, Rall says he was not aware of the extent of the persecution of Europe's Jewish population. His wife, Hertha, a physician who had treated him when he was recovering from his back injury, helped several Jews escape to Great Britain in 1938. The Gestapo watched her home for the duration of the war, even though her husband was one of the Luftwaffe's top pilots. Rall found out about the Nazi concentration camps in 1945, reading about them in *Stars and Stripes*, an American military newspaper he was given while being held prisoner by U.S. forces.

During his talk, Rall did not discuss his experiences after the war, but his biography explains that no German employer or university wanted anything to do with a Luftwaffe ace. He went from being a national hero to a national disgrace. For years he struggled to find a foothold. His break came in the 1950s, when the North Atlantic Treaty Organization decided to accept West Germany as a member and allow it to establish a modest air force. Even though Rall had flown piston engine Bf 109s, rather than NATO's far faster and more advanced F-84 and F-86 jets, there was no replacing his experience as a seasoned fighter pilot. In 1956 he was appointed to West Germany's Bundeswehr air arm with the rank of major. After retirement in 1975, Rall served on the boards of several international corporations, including General Electric.

For most of his talk, Rall spoke of dark things with composure and at times humor. But just as he seemed ready to head off the stage, he turned around, his face flushed with emotion, and said, "All of these opponents [former Allied pilots] became good friends. This is what really, really makes me satisfied." He paused, waiting for some sort of response, some gesture of reconciliation.

The crowd applauded.

—Mary Collins

REUNION

DANE PENLAND

On the morning of January 12, the National Air and Space Museum's Steven F. Udvar-Hazy Center had a distinguished visitor with an unusual credential: A former Luftwaffe pilot, Wilhelm Kriessmann is one of the few living airmen to have flown the Arado Ar 234 Blitz twin-jet bomber. The Museum's Arado, the sole surviving example of the type, is part of the World War II collection, along with the Messerschmitt Bf 109 (see "German Tales From the Russian Front," opposite). Kriessmann, an Austrian by birth with a youthful bearing that belies his 85 years, was 18 when he was sent off to Luftwaffe boot camp during World War II. After training as a bomber pilot for Germany, he was assigned to the Eastern front, where he flew ground support missions against the Soviet army. Eventually he got an assignment to ferry aircraft, and his logbook shows he made flights in 25 Ar 234s—including one whose serial number matches the one at the Udvar-Hazy Center. Kriessmann noted that despite a speed of 450-plus mph, the Arado and other Luftwaffe jets, such as the Messerschmitt Me 262, "were vulnerable during takeoff and landing operations, when they could be picked off" by Allied fighters flying on low-level sweeps.

Today Kriessmann resides in California's San Francisco Bay area.

—George C. Larson

VISITOR INFORMATION

Location The National Air and Space Museum is on the National Mall, along Independence Avenue SW, between 4th and 7th Streets, Washington, D.C. The Steven F. Udvar-Hazy Center is at 14390 Air and Space Museum Parkway, Chantilly, Virginia, near Washington-Dulles International Airport.

Hours The Museum on the Mall and the Udvar-Hazy Center are open from 10 a.m. to 5:30 p.m. every day except December 25.

Food The Museum on the Mall has the Wright Place Food Court, which offers selections from the menus of McDonald's, Boston Market, and Donatos Pizzeria. The Udvar-Hazy Center offers food service from Subway (sandwiches, chips, cookies, and drinks), located at the south end of the main hangar. A food court is scheduled to open by June.

Shopping Both the Museum and the Udvar-Hazy Center shops offer a variety of souvenirs, books, DVDs, models, posters, clothing, and toys. A selection of these products can be purchased online at *SmithsonianStore.com*.

NASM Express Shuttle Bus A shuttle runs round-trip between the Museum and the Udvar-Hazy Center from 9 a.m. to 5 p.m. Tickets cost $9 to $12, depending on visitor age and number in party. They sell out quickly, so visitors are encouraged to purchase them in advance at (202) 633-4629.

Curator's Choice
Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at the Steven F. Udvar-Hazy Center. Meet at the nose of the SR-71 spyplane at noon. Apr. 7, "James A. Van Allen's Legacy: The Early Explorer Satellites"; Apr. 21, "James H. Doolittle, 1942–45"; May 5, "The V-2 Engine and Turbopump Cutaways"; May 19, "The Boeing P-26 Peashooter."

A Navy Brat at Pearl Harbor

For my 75th birthday, my granddaughter gave me a deck of playing cards, each card showing three silhouettes of a World War II airplane, the type used by the armed forces for aircraft recognition. At once I was back on Oahu, where I was 13 and in the eighth grade when Japanese aircraft attacked Pearl Harbor on December 7, 1941.

For at least a month or two, all schools on the island were closed for fear of further attacks, especially bombing raids. Before the schools reopened, deep trenches were dug in the red volcanic earth of the schoolyards, and we were instructed to run to them for protection in case of an attack.

On our way to school that first morning, in February 1942, our Navy school bus passed through the towns of Aiea and Pearl City, enabling us to get our first look at the ruined battleships of the Pacific fleet. Thick patches of black oil still floated on the water and soaked the sand on the narrow beaches of Pearl Harbor. The upside-down hull of the USS *Oklahoma* and the twisted superstructure of the USS *Arizona* were a sickening sight.

Throughout Honolulu and across the island, the signal for a gas attack was the heavy and constant beating of metal bars on automobile brake drums. For the war emergency, the drums had been stripped from autos in wrecking yards and hung from wire in conspicuous sites.

One of our family friends, Thomas Nides, a first class electrician's mate and shipmate of my father, was entombed in the *Arizona* at his battle station on the after-gyro. Tommy's son and daughter were now without a father.

Upon our return to classes, we were drilled in air raid procedures. When the alarm sounded, we would file from our classrooms and head to our designated trenches, where we were cautioned not to look skyward during an air raid, because, we were told, low-flying Japanese pilots would spot the white of our upturned faces. Hunching down supposedly would keep us hidden.

We had all been issued gas masks and trained to prepare for a gas attack. Throughout Honolulu and across the island, the signal for a gas attack was the heavy and constant beating of metal bars on automobile brake drums. For the war emergency, the drums had been stripped

from autos in wrecking yards and hung from wire at conspicuous sites.

Civilians were issued army-type gas masks of gray rubber with the filter canister hanging beneath the chin. My little brother and I, as Navy dependents, carried Navy-issued gas masks of black rubber with a small canister mounted on each cheek. We were told that the Army canisters lasted for an hour or two, and that our double canisters were good for twice that. I don't know if that was true, but at the time we believed it, and it was of dubious comfort knowing that we might last longer than our classmates and teachers.

Every student attended mandatory first-aid classes conducted by Civil Defense and Red Cross volunteers. We were taught how to bandage wounds and use a square piece of unbleached muslin to splint broken bones and form slings and tourniquets. Along with our gas masks, we carried these folded squares with us at all times.

In addition to knowing the names of all the bones, we were trained to stop arterial bleeding by targeting various pressure points.

The most exciting classes were the instructions on putting out incendiary bombs. Buckets of sand were placed strategically around the classrooms and the hallways. If an incendiary bomb struck, we were to dump the sand on the burning bomb to suffocate it. We were told not to look directly at the bright magnesium fire, but to crawl on our bellies along the floor, pushing a wall of sand ahead of us. Under no circumstances were we to douse the magnesium with water, which would only scatter the material. Each of us secretly hoped we would not have to do any fire-bomb extinguishing.

Things changed dramatically in our wood shop class. No longer were we building birdhouses. Instead, the teacher distributed dozens of small cardboard boxes containing several pine blocks and instructions on the construction of miniature airplanes. We were to make models for the Army, Navy, and Marines on the island. Our shop instructor, Mr. Tipping, was to ensure that the models were made to precise specifications, for these were government property, to be used in aircraft recognition classes for gunners.

On the frantic night of December 7, U.S. gunners had shot down in error four U.S. Navy fighters from the USS *Enterprise* attempting to land at Ford Island, in the middle of Pearl Harbor. As the sky lit up with tracers, we had cheered, thinking a night attack had been thwarted. In the morning we learned the sad reality.

I think I made two Messerschmitts and one or two Republic P-47 Thunderbolts. I wanted to do a Lockheed P-38 Lightning, but a friend had beat me to it. Everyone wanted to make Grumman F4F Wildcats and Curtiss P-40 Warhawks because they were easy.

We were allowed to pick which models we would build. I began with a twin-engine Messerschmitt Bf 110 fighter. Following the step-by-step procedures outlined in the kits, we traced the patterns on the blocks and cut them out with band saws. Next, we did the coarse hand-shaping with wood chisels and knives, followed by rough and then smooth sanding. Each piece was matched against a set of templates. Wings had to have the proper chord and span, and airfoils and fuselages had to be of the proper shapes. The various bulges of air coolers, cockpits, engine nacelles, and empennage fins had to be accurate.

When all the parts passed muster, we fastened and glued them in place. After Mr. Tipping's final inspection, we painted each model dull black.

For some reason, models of the stubby F2A Brewster Buffalo were not in the lot. I had seen one on the dock at the Naval Ammunition Depot, West Loch, where we lived. My brother and I had climbed up on the wing and peered in the cockpit. This one, which had belonged to the Marines at the Ewa airfield, was being shipped back to the mainland for repairs. One propeller blade had a neatly rounded bullet hole.

I think I made two Messerschmitts and one or two Republic P-47 Thunderbolts. I wanted to do a Lockheed P-38 Lightning, but a friend had beat me to it. Everyone wanted to make Grumman F4F Wildcats and Curtiss P-40 Warhawks because they were easy. Other classmates were turning out Japanese Zeros and Val and Betty bombers. All were handed over to the Army for distribution, with the name and school of the builder included. Ours was Robert Louis Stevenson Intermediate, near the slopes of Punchbowl Crater.

Early in 1941, my father had been called out of retirement as a chief warrant machinist, promoted to lieutenant junior grade, and assigned to the ship repair facility. After the attack, he helped salvage the Pearl Harbor wrecks and patched up battle-damaged aircraft carriers returning from the South Pacific. Then, in 1942, all military dependents were loaded on ships and evacuated to the mainland. Honolulu was our home, and we didn't want to leave.

To keep our family together, my mother was able to get an exemption as an essential war worker. She signed on to fill a shortage as an operator for the Hawaiian phone company. Then, in the middle of 1943, my father was ordered to Camp Shoemaker in California as a battalion commander. We were told that he must comply with the orders, but my mother was now considered an essential emergency communications worker, indispensable to the war effort, and could not be released. After a flurry of written and oral appeals, we were granted an exemption, and moved as a family to California, where we remained together through the rest of the war.

I wish the little black models had been returned to their builders after the war. My grandchildren would have prized them.

—Arthur R. Lee

Einstein's Wing

DAVID CLARK

His far-reaching ideas have changed the way we see the universe, and yet as the world honors the centennial of Albert Einstein's quantum theory this year, we should also recall, with no disrespect, the great professor's occasional flops—specifically, Project LVG, Einstein's experimental aircraft.

In fairness, Einstein surely had much on his plate during the winter of 1915; still engrossed in important work on relativity, and yet never too busy, as two of his biographers noted, to take up a topic "for intellectual curiosity." Perhaps inspired by his recent success as an expert witness in a patent dispute regarding the Sperry gyrocompass (Einstein first worked as a patent examiner), he was drawn to the question of how the aerodynamics of aircraft could be optimized.

"Where does the lift come from that allows airplanes and birds to fly?" Einstein asked in his August 1916 paper "Elementary Theory in Water Waves and Flying." After finding "not even the most primitive answer in the published literature," he waded into fluid dynamics, finally formulating his own unique solution for increasing a wing's ability to generate lift: an airfoil with a strange mid-chord arch, resembling a hissing cat's back.

Einstein's proposal ultimately landed on the desk of Paul Ehrhardt, technical manager at Luft-Verkehrs-Gesellschaft aircraft works in Berlin. Ehrhardt had launched his flying career in 1909 with a two-minute stint as a passenger beside Orville Wright, and went on to earn the honorific of ace in World War I. Recognizing that the contents of Einstein's missive were "far beyond his capacity to fathom," he forwarded the fat envelope of figures to Engineering. A lengthy meeting with Einstein followed.

Further evaluation included testing in the Göttingen Versuchsanstalt fur Aerodynamik wind tunnel, and finally the construction of a full-scale prototype that Ehrhardt himself would fly. A pair of Einstein's wings were fitted to a World War I LVG type D9v; "D" for *doppeldecker*, a biplane.

After a protracted takeoff run, the craft lifted, then executed an uncommanded roll that its pilot would later say he was fortunate to survive. Ehrhardt somehow landed, "overjoyed to find himself on firm ground and still in one piece," a colleague reported. Years later, Ehrhardt remembered the aircraft's penchant to "dip" its tail as the wing, set at zero angle of incidence, attempted to assume a positive angle of attack, and compared the motion to "a waddle—something like the flight of a pregnant duck." Still, Ehrhardt and Einstein remained friends, even joking about the incident.

"The great theoretician had failed," wrote Carl Seelig, one of Einstein's early biographers. Original polar diagrams (graphs used by aircraft designers to relate an airfoil's lift and drag coefficients) from wind tunnel tests still exist in a private collection. They reveal that of 99 airfoils tested against Einstein's *katzenbuckelflache* (cat's back wing), 97 had higher maximum lift-to-drag ratios and maximum lift values.

So where had the great genius gone wrong? In applying Bernoulli's principle about air flowing over a curved surface, Einstein had in effect concluded that air would travel faster across the top of his humped wing simply because, as he later diagrammed for Ehrhardt, "the air had farther to go." If that sounds familiar, it is because numerous investigators (quite independent of Einstein) have made the same error. This incorrect explanation for lift still turns up in popular literature; even this magazine has printed it ("Mach 1: Assaulting the Barrier," Dec. 1990/Jan. 1991).

The correct explanation of how a wing flies, a seemingly simple question, would tax many minds, and even today aerodynamicists still debate whether the downwash of air under the wing, the circulation of air around it, or other factors best explain what we see birds and airplanes do. Still, Einstein's acceptance of an uncharacteristic flub remains an example of the man's humility. "That is what can happen," Einstein wrote to Ehrhardt in 1954, "to a man who thinks a lot, but reads little."

—Nick D'Alto

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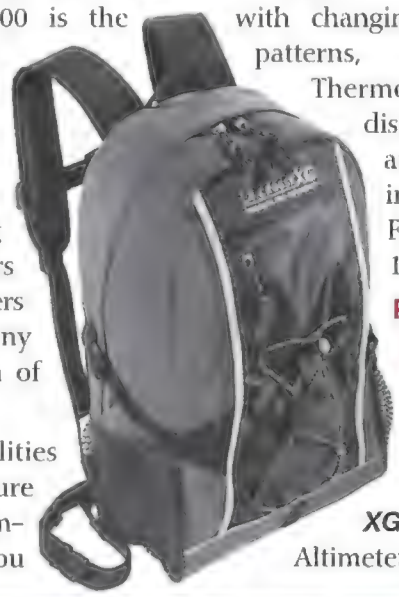

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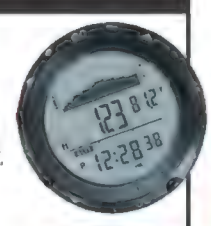

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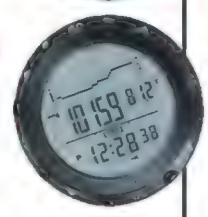

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THE SPACE SHUTTLE RETURNS

After two years of hard work and soul-searching, NASA heads back into orbit.

Last December, the external tank that will soon thunder off the launch pad bolted to the space shuttle *Discovery* lay on its side in NASA's Michoud Assembly Facility, near New Orleans. It was a pale, pretty yellow. The insulating foam applied to its metal skin would later darken with exposure to ultraviolet light, eventually turning the familiar reddish orange color of the tanks we see on the launch pad.

A dozen technicians were working at various levels of a multi-story scaffolding erected around the tank, which they refer to as ET-120—the 120th external tank built at Michoud. Off to the side of the broad scaffolding, several clear plastic garbage bags held pieces of foam that had been cut away. I reached into one and pulled out a hand-size piece. I was shocked at how little it weighed; I could have been holding a Kleenex. But this is the stuff that cracked a hole in the leading edge of the space shuttle *Columbia*'s wing, resulting in the vehicle's disintegration and the death of all seven of its crew on February 1, 2003. When the culprit was discovered, the people at NASA and tank builder Lockheed Martin Space Systems—people who had worked with the foam for twenty-odd years—were just as shocked as I was.

Neil Otte [pronounced "OTT-ee"] is NASA's chief engineer for the External Tank Project at the Marshall Space Flight Center in Huntsville, Alabama, though he has spent much of his time at Michoud over the past two years. "The morning of the *Columbia* accident," Otte said, "I know personally—when I got called and went into Marshall because I was on the investigation team—[the foam] truly didn't cross my mind as being a potential candidate. When [the investigation] led to the left wing, when it led to the foam strike, yeah, it hit us hard. Because we didn't know that our foam could do that type of damage. And we felt responsible. So, yeah. It hit us hard."

SCOTT ANDREWS

Before launching Discovery, *NASA must be sure that foam won't fall from the external tank (opposite).*

At the direction of the Columbia Accident Investigation Board (CAIB), technicians at Michoud cut away foam from other tanks, the first time in shuttle history that the inside of the material had been examined after being applied. What they found, said Otte, "is that the structure of the foam that we were putting on in certain areas was not the structure that we thought we had in there."

Meanwhile, at the Johnson Space Center in Houston, engineers testing the large, curved panels of insulation that form the leading edge of the shuttle's wing were also finding surprises. This reinforced carbon-carbon (RCC) material turned out to be more vulnerable than anyone knew, and the problem of repairing it in orbit more challenging than anyone thought. The early hope that the next mission, STS-114, could launch in the spring of 2004 quickly faded. The date was postponed to fall, then to March 2005, then May.

At Michoud, Marshall, Johnson, and

by **LINDA SHINER**

other NASA centers, and at government labs and contractor facilities around the country, thousands of people have been trying for two years, at an estimated cost of $2 billion, to better understand a machine NASA has been flying for nearly a quarter of a century. The work has been guided by 29 specific recommendations from the CAIB, 15 of which need to be addressed before the shuttle flies again. One requirement, though, has stood out from the rest. As NASA head of space operations Bill Readdy told a group of reporters in January 2004, about six months after the CAIB report was released, "Return to Flight has always been driven by fixing the tank."

The reason the surface of the bullet-shaped container—all 12,620 square feet of it—is covered with insulating foam is to keep the supercold propellants within from boiling away in the Florida sun. To stay liquid, hydrogen must remain at –423 degrees Fahrenheit; oxygen at –298 degrees. The insulation also helps to keep ice from forming on the tank.

Computer-controlled machines spray the smooth areas of the tank with a polyurethane foam, while technicians use spray guns to apply another foam called BX-265 to irregularly shaped areas—around propellant feedlines, for example. BX-265 is similar to foam used in refrigerators and roof insulation, but has more exotic thermal and cryogenic properties, and was formulated especially for NASA.

"You spray it down and it goes on about like water," said Otte. "Then you build it up in layers as you spray it on. When you spray it around [protuberances], the foam can lap over itself and create voids. It can cause pressure as it's expanding. If the geometry is right, it can pull on the foam that you just sprayed underneath it. Those are the types of features that we saw inside the foam structure at the bipod ramp."

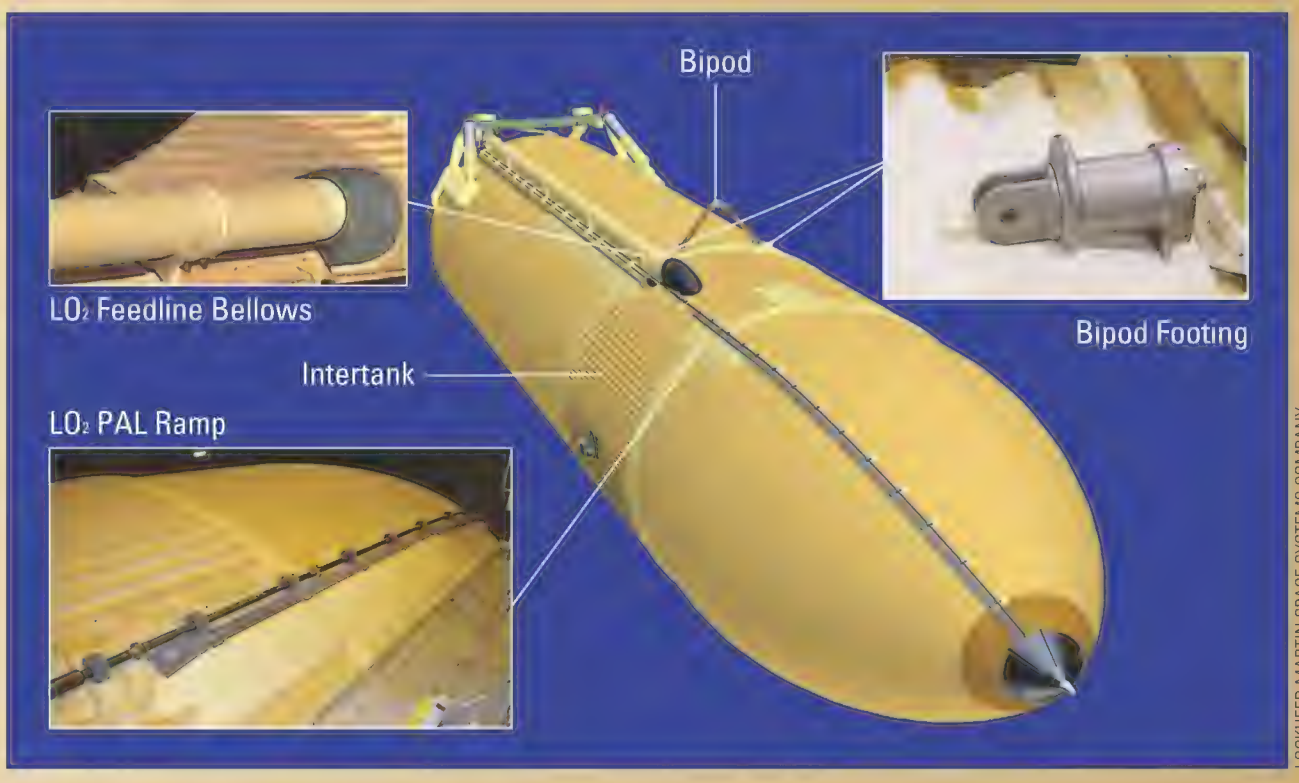
Until 2003, each tank had two such ramps—wedges of foam covering the feet of a V-shape (hence bipod) fitting that connects the orbiter to the tank. Oddly, the right one had never been known to shed foam; only the left was troublesome, and it was the instrument of *Columbia*'s destruction. The irony is that the foam ramps were applied to prevent ice from forming on the bipod attachment post; NASA feared that during launch, ice on the post could break away and damage the orbiter.

While the workers at Michoud were autopsying bipod ramps and other areas identified as tough sprays, engineers in the laboratory at Marshall were placing mockups of the tough-spray areas in thermal-vacuum chambers, which mimic the temperature and pressure extremes of launch. The engineers now have a failure curve: For a given void size at a given depth, they can predict the size and weight of a divot of foam that would be released during launch. Despite many attempts, they were unable to duplicate the failure at the bipod ramp.

If NASA had ever considered finding a new insulating material, it was only the briefest thought. "Could we develop a foam that could perform better structurally? Yeah, we probably could," said Otte. "But it typically takes us four to five years to develop a totally new foam system. And then of course we have to develop the processes to put it on and all the controls that we'd have to put in place."

LOCKHEED MARTIN SPACE SYSTEMS COMPANY

Left: Kennedy Space Center technicians inspect a reinforced carbon-carbon panel before installing it. Below: STS-114 Commander Eileen Collins studies the work being done on the external tank's intertank flange.



LOCKHEED MARTIN SPACE SYSTEMS COMPANY

External Tank Danger Zones

A new shape for the foam covering the liquid oxygen feedline bellows—sections that let the line flex—helps prevent ice formation. The titanium-housed bipod footing will fly uncovered; foam hides the heaters beneath it. Foam is hand-sprayed on the protuberance-air-load ramps, which prevent airflow around cables. Bolts joining the intertank to the hydrogen tank have been reversed (below), and each stringer is injected with foam.

Otte is an engineer in his 40s with a compact, athletic build and the air of a man proceeding methodically through a long list of action items. As he explained how the program he helps manage had gone wrong and what is being done to correct it, his tone was at times chastened, at other times confident in the investigation and NASA's ability to find and fix problems. Armed with an immense knowledge of his program—Otte has worked with the external tank since 1987—he seemed ever so slightly defensive of the agency "culture," a word the CAIB used to describe an organization-wide weakness, which the investigators partly blamed for the accident. "We've got 2,000 people, counting Lockheed Martin and NASA employees, who do this because they believe that this is what the country needs to do," Otte said. "Everybody has to have a paycheck, don't get me wrong, but these guys are involved in this because they believe in what they're doing. And they're proud of what they do. But they also understand that this is a risky business and they accept that. [Risk] is something that anybody that works shuttle understands. It's something the American people need to understand. If you're going to work shuttle and if the American people are going to fly shuttle, we have to be prepared to accept risks. If we're not, we shouldn't be in this business."

ET-120 has no bipod ramps. Unable to duplicate that fatal failure in the laboratory, the project office eliminated the foam covers altogether. Instead, ice formation will be prevented by four rod-shaped heaters at the feet of the bipod attachment post. The radical changes in the external tank program are not in structure, however. The real change is in the methods by which foam is applied to sections of the tank where foam had broken off…or could.

The Vehicle Assembly Building at Michoud is so vast it doesn't feel like a building; it feels like space, which happens to be enclosed. On the frequent steamy days in Louisiana, Michoud workers who walk for exercise do their miles in the air-conditioned comfort of the VAB.

Before entering the areas where workers were applying foam to ET-121, I was asked to remove my earrings and watch, seal them in a Ziploc bag, and carry them in a small waist pack with a Velcro closure. (A manager helped me wrap tape around my wedding and engagement rings.) Foreign object debris, or FOD, is something NASA, Lockheed Martin, and the United Space Alliance, the NASA contractor that prepares and helps launch the shuttles, have always taken seriously, though not seriously enough, according to the CAIB. Because FOD was the subject of one of the CAIB return-to-flight recommendations, new requirements and procedures have been established. At the beginning of every shift at Michoud, workers and supervisors spend at least 15 minutes discussing safety precautions, including how to search for and dispose of FOD.

Leon Richard (pronounced ri-SHARD, in the style of New Orleans, where he grew up) is in charge of "large acreage applications" for the external tank thermal protection system. He is a personable man who, even after 28 years with Lockheed Martin, clearly relishes the operations in the VAB. At one point in our tour, Richard, who worked his way up to senior manager from installation mechanic, swept his arm out over the great space and said, "This is my American dream."

Besides managing the machines that spray most of the tank with foam of a uniform thickness (after some machines spray it on, other machines shave away excesses), his crew applies foam to the intertank flanges, where big sections of the tank are joined. The greatest amount of foam loss, historically, has been from this area. One reason: The surface is covered by complex ridges and bumps.

In the bay where ET-121 was being outfitted, we rode an elevator 101 feet up to the intertank. There Richard showed me the crevices that had to be filled and the protrusions that had to be carefully covered. "We can't have any voids," he said, "which is what got

us in this pickle in the first place."

The intertank has 108 hollow stringers and 52 solid ribs, stiffening structures that help the huge tank stand up to the stress imposed by seven million pounds of thrust. Around each flange, 178 bolts must be carefully covered, first with a sealant, then with foam. "It's 60 feet all the way around," said Richard. "Sixty tedious feet." Watching the painstaking work reminded me of scenes I'd witnessed at the Kennedy Space Center, where technicians removed individually numbered shuttle tiles, inspected and reapplied them, while others sewed insulation blankets beneath the orbiter's skin. For all its sophistication, the space shuttle has many parts that are essentially handmade.

Five sprayers were trained to apply foam to the intertank, and Richard hopes to certify five more. One crew is trained for "closing out," or finishing, the bipod area, another for protuberance-air-load (PAL) ramps, and another for the longeron, a structural support for the tank's aft orbiter attachment struts. Before *Columbia*, a close-out sprayer could have done the applications on any of those areas; today the workforce is divided into specialties.

Ron McQueen, a production supervisor of foam applications who has been with Lockheed Martin for 23 years, watches a video screen while two sprayers apply foam. A third sprayer is on hand only to watch what the other two are doing. Immediately after the application is complete, the video is run again, and the sprayers, the quality control people, the production supervisor, and several engineers watch the replay, looking, says McQueen, to see if anything has contaminated the foam, or if a void has developed, FOD has been introduced, or more than 45 seconds has elapsed between the first spray and the second. If they spot a defect over a large enough area, the foam will have to be removed and replaced.

"These new [procedures] were developed over a long period of time," says McQueen. "On the bipod, we probably worked for a year and a half coming up with a new [process], which we were all involved in—the supervisors, the hourly employees. [NASA and Lockheed Martin managers] took our suggestions right along with theirs."

Application is now a six-part process, not counting the video review and other quality control steps. Before the foam is applied to a real tank, it is applied to a high-fidelity mockup of the tank area to be sprayed. The sprayer applies foam to a "lead-in" test panel, then to the mockup, then to a "lead-out" test panel. All three are later dissected to see if any voids or weak areas developed in the foam. The steps are repeated for the tank that will eventually be sent into space, but only the lead-in and lead-out panels are dissected, unless the technicians see something unusual.

And yet, despite all the safeguards, when *Discovery* is launched this spring, some foam will almost certainly shed from the tank.

Wayne Hale, the deputy space shuttle program manager, explained last December that NASA managers interpreted the CAIB's recommendation as "eliminate all debris that could cause damage." After hundreds of tests, the engineers determined that a piece of foam weighing as little as .023 pound, if it came off the top of the tank, could damage the wing leading edge so severely that safe reentry would be questionable. (The piece that struck *Columbia*'s wing weighed an estimated 1.67 pound.) NASA believes that no debris larger than .008 pound will come off; that leaves a safety margin of only .015 pound.

"We were very clear from day one...that if in fact the requirement becomes 'No debris,' we are not going to be able to make it—not with this foam system," Neil Otte said.

When the CAIB required "an aggressive program to eliminate all External Tank Thermal Protection System debris-shedding," was it envisioning zero debris? That's the type of question debated by a group of 26 experts appointed by NASA Administrator Sean O'Keefe in June 2003, as NASA began responding to the CAIB's preliminary recommendations. The Return to Flight Task Group, co-chaired by Apollo astronaut Thomas Stafford and shuttle astronaut Richard Covey, who piloted *Discovery* in 1988 on the shuttle's first flight after the 1986 *Challenger* accident, shadowed NASA's employees and contractors at every step of their return to flight, questioning their analyses and decisions and compiling its own report, to be delivered to the administrator about six weeks before the next shuttle is launched. (The task group reports to a different administrator from the one who chartered it; O'Keefe left the agency in February to return to academia.)

The task group's job is to make an independent assessment of NASA's response to the CAIB's 15 return-to-flight recommendations. It is a self-described "umpire calling balls and strikes in a zone defined by the CAIB." Last December, the umpire seemed disposed to approve NASA's solution to external tank debris-shedding. Dan Crippen heads the group's panel evaluating actions taken to improve NASA management. A former director of the Congressional Budget Office, Crippen holds a doctorate in public finance and is the only one of the group's leaders who had never worked in the space program.

"The CAIB clearly understood some limitations," he said at a December press conference. "Their intention was to eliminate all debris. Well, if they thought that was possible, they wouldn't have gone on to say, 'Oh, by the way, you ought to be able to inspect for damage, you ought to be able to repair damage.' Because if you had eliminated all de-

bris, then you wouldn't need that. So they clearly understood in their own discourse that their recommendations were subject to imperfection."

Reading the first four CAIB recommendations, the ones that directly address the physical cause of the *Columbia* tragedy, you can hear *What if*? whispered after each one, as if the committee were trying to lock the shuttle's survivability inside a strong box, then inside a combination safe, then inside a bank vault. In the CAIB plan, foam will not shed from the tank. *But what if it does*? Then the RCC panels on the orbiter's leading edge will be more impact-resistant than they were. *But what if they're not*? Then the astronauts will be able to inspect and repair them. *But what if they can't*?

There's no doubt that the next shuttle flight will be the most carefully watched in history. To the 14 tracking cameras active at the Florida launch site, NASA is adding nine more. There are new cameras on the external tank and solid rocket boosters, and more are planned. Department of Defense telescopes, which could have seen the damage done to *Columbia*'s wing had NASA requested photographs of the craft while it was in orbit, will view every shuttle from now on as a matter of course. (The CAIB censured the STS-107

Trouble can't hide from (clockwise, from right) improved cameras to track the shuttle's ascent, a sensor-carrying boom to scan RCC panels in orbit, and a new camera on the orbiter to photograph the tank.

Three reusable shuttle main engines gulp 1,035 gallons of propellants per second to produce 1.2 million pounds of thrust, an ultra-high-pressure operation that contributes a significant amount of risk to a shuttle launch.

In eight and a half minutes, the tank has done its job. It falls away and burns up on reentry.

mission controllers for not availing themselves of these assets after seeing foam fall from the tank.)

If a strike should occur during launch, its impact will be detected by 88 accelerometers and temperature sensors newly installed inside the wing. Even if the sensors register no impact, the astronauts, once in orbit, will deploy a new piece of hardware, the Orbiter Boom Sensor System. Attached to the shuttle's robot arm, the 50-foot boom carries two laser imaging systems and a low-light black-and-white television camera that will scan the shuttle's nose cone and the 44 RCC panels on the wings' leading edges to provide three-dimensional maps of those areas.

In addition, on flight day three, before *Discovery* docks with the space station, STS-114 Commander Eileen Collins will perform a pitch-around maneuver 600 feet from the station, exposing the craft's tiled underside to photography by the station crew. The two astronauts on the station will have about 100 seconds, as the shuttle turns a slow somersault at a rate of .75 degree per second, to scan the shuttle's underside for damaged tiles and take pictures of specific areas, like the seals over the main landing gear, that experience high heating.

"They will almost immediately downlink those digital photos to mission control," says Collins, "and once we've docked, we'll be able to go into the space station and see the pictures."

Collins is pure astronaut. A thoughtful, exuberant pilot, with the no-problem-too-big attitude the astronauts are famous for, she is the only woman to have commanded a space shuttle mission. STS-114 will be her second command. (She is also a mother of two, and there is a remarkable interview on NASA's Web site [see link at *www.airspacemag.com*] in which she describes explaining the *Columbia* accident to her eight-year-old daughter.) The pitch-around maneuver has never been done, and Collins admits, "Initially it was a big concern to shuttle management." In fact, it violated one of the program's long-standing safety rules: When a shuttle is in close proximity to another spacecraft, the target must be in sight at all times. For this maneuver, the space station will be out of the astronauts' view for six or seven minutes.

Over time, shuttle managers have satisfied themselves that the risk is acceptable. "I've been flying this [in the simulator] for over a year and a half," Collins says. "We've made some good changes to make it safer."

Even if the astronauts spot trouble during the inflight inspections, they won't be able to repair the kind of damage that brought down *Columbia*. With just months left before the STS-114 launch, NASA and its contractors were still struggling to develop materials and techniques to repair tiles and RCC.

"The space agency gave up on tile repair in the 1980s as an impossible task," says NASA's Wayne Hale. Although some progress has been made since, in an emergency the STS-114 astronauts will have only a minimal repair capability—applying a patch or using a kind of caulk gun to fill holes were the two leading repair methods proposed as of early this year. This CAIB mandate has proven among the hardest to meet, and NASA may only be able to satisfy the letter-of-the-law requirement for a "capability to effect emergency repairs."

Foreseeing the difficulties with repair, NASA added another safety measure for STS-114: the rescue shuttle. If the astronauts make it to orbit but can't return to Earth, they will dock with the International Space Station and wait for another shuttle to arrive and take them home. The station has enough oxygen, food, and other supplies to host seven refugees for 45 days.

Early last year, in a self-imposed directive, shuttle program managers decided to make rescue capability a requirement for the first few flights. Dick Covey's Return to Flight Task Group has endorsed the idea. Yet when Covey piloted *Discovery* after the *Challenger* accident, there was no space station to offer shelter and no second

shuttle ready to rescue him and his crew. His commander on that flight was Rick Hauck, a veteran of three shuttle flights and now the president and CEO of AXA Space in Bethesda, Maryland, which insures commercial satellites. Hauck, who has led National Research Council studies on space program risks, calls himself an interested but distant observer of the return-to-flight process. I asked him why he thought a safe haven was required now, when it hadn't been for his flights.

"After *Challenger* we were dealing with an accident that destroyed the shuttle going uphill," he says. "So the question of being safely in orbit and then being able to be rescued was not deemed to be the highest likelihood. *Columbia* changed that thinking."

What has not changed, despite *Columbia*, is the judgment that the ascent to orbit is the most dangerous phase of any shuttle flight. According to NASA's risk assessments, the solid rocket motors and space shuttle main engines are as likely to cause a catastrophic accident as all other shuttle systems combined.

Launching a second shuttle is an action that would be taken only in the direst emergency and, as NASA has admitted in its implementation plan, would put the second crew at risk. "I'm sure the astronauts would take that risk in a moment," says Henry McDonald, former director of NASA's Ames Research Center in California and now a professor of engineering at the University of Tennessee. "The question is whether we ought to let them."

In 1999 McDonald headed a panel to scrutinize shuttle operations after two close calls on the STS-93 mission grounded the shuttle fleet. At takeoff, a pin broke loose and ruptured cooling tubes in one of the three main engines, affecting its performance. Separately, during the same launch, two of the engine controllers unexpectedly shut down. (The commander of the mission was Eileen Collins.)

McDonald's panel identified problems with the shuttle program very similar to the ones described by the CAIB more than three years later. He is still "dreadfully disappointed" that more of his panel's advice wasn't followed. More important than a rescue shuttle, he believes, is that the program be constantly subjected to neutral outside review. "Many times [the] people who are candidates for external reviewers may be retired or former employees that share many of the views," says McDonald. "They have the expertise but they don't have the critical view of the vehicle that is necessary to introduce what some people have called 'fresh eyes.'

"Some of the reviews are led by former astronauts," he adds. "I happen to have a great deal of admiration for astronauts. I think they're terrific people and extremely brave. But their acceptance of risk levels is way beyond mine."

In what was probably its toughest recommendation, the CAIB called for NASA to do a thorough recertification of the shuttle "at the material, component, subsystem, and system levels" if it planned to keep operating the vehicle beyond 2010. Early last year, the Bush administration decided to retire it instead. When the space station is complete, in another 28 missions, that will be the end of the space shuttle.

Although NASA would like to reach that milestone as soon as possible, in part to free money for Bush's new moon-Mars exploration program, there's nothing sacred about 2010, says shuttle program manager Bill Parsons. "The guidance I received is to look at this as a 28-flight profile," he says. "Don't get caught up in 2010. It's not the driving factor by any means." Parsons is well aware that the CAIB criticized NASA management for allowing schedule pressure rather than safety to guide decision-making in the months before the *Columbia* accident. That won't happen again, he vows.

Because NASA plans to phase out the shuttle, last December it canceled several upgrades including an "advanced health management system" for the main engines. This suite of sensors and computers would have monitored the engines so that if something started to go wrong, the onboard computers would react instantly. Testifying before a Senate subcommittee in September 2001, NASA head of space operations Bill Readdy said the proposed update would reduce the risk of catastrophic engine failure by up to 40 percent. But leaving real-time decisions about engine throttling to an automated system entails its own risk, says Parsons. Much more testing would have to be done, and given the shuttle's limited life expectancy, he says the money would be better spent on additional ground tests to improve engineers' understanding of the engines.

When I asked Eileen Collins if she spent time worrying about main engine failures, she said that "worrying" is not the word she would use. "I spend time training for failures," she said, "because we have to be ready for that."

Approximately two weeks before the launch of *Discovery*, NASA's senior managers will hold a Flight Readiness Review, a final meeting to consider any questions left over from the hundreds of program reviews leading up to launch. The managers will have guidance from Covey's Return to Flight Task Group, which will already have reported its findings. And at some point they will agree that everything possible has been done to mitigate the dangers of launching a vehicle into space.

But what if it hasn't?

There are seven astronauts—and thousands of people working every day to ensure their safety—who will still be willing to take the risk.

DESPOTS ALOFT

HOW MUSSOLINI, HITLER, AND STALIN CAPITALIZED ON THE AIRPLANE IN WORLD WAR II.

BY VON HARDESTY

By the summer of 1941, Operation Barbarossa, Hitler's bold plan for the invasion of Soviet Russia, was in full swing. With the Soviet armies in retreat, Hitler invited his Italian ally, Benito Mussolini, to fly with him to the war zone in his Fw 200 Condor, the *Immelmann III*. The journey would allow Hitler to savor his triumphs in the east and to view the conquered Ukraine, where his Army Group South had destroyed 20 enemy divisions and taken over 200,000 prisoners. Hitler firmly believed that Joseph Stalin and his Bolshevik regime now faced extinction.

The trip to the Ukraine called for a flight of over 600 miles to an airstrip at Uman´, in an active sector of the front 150 miles south of Kiev. The weather proved ideal—little turbulence and a nearly cloudless sky. Joining Hitler and Mussolini for the flight were Nazi Foreign Minister Joachim von Ribbentrop, SS head Heinrich Himmler, and the Italian ambassador to Germany, Filippo Anfuso. Santi Corvaja in his *Hitler and Mussolini, The Secret Meetings*, records Anfuso's vivid account of the unspoken anxiety aboard: "They were all thinking of the front pages of the newspapers had we all crashed together." The Soviet air force had been nearly destroyed, so it posed no real threat; still, the Luftwaffe deployed an escort of Messerschmitt Bf 109 fighters to ensure the Führer's safety.

But Hitler and his personal pilot, Hans Baur, encountered another danger: On the return leg, Mussolini asked his German host if he could fly the airplane. Mussolini had earned his pilot's license in the pre-war years and fancied himself a talented aviator. Hitler acquiesced but prudently instructed Baur to remain at the controls.

Once Mussolini entered the cockpit, Hitler nervously returned to his *Führersessel* (special leader's seat). Under the watchful eye of Baur, Mussolini put the Condor through several shallow banks and other maneuvers and expressed great admiration for the airplane's responsive controls. After an hour, Mussolini finally returned to the cabin, to the relief of all. Anfuso wrote of the incident, "I'm sure the joke was not at all to Hitler's liking. The SS must have thought of it as an attempt to murder the Führer. Not knowing what to do, they stared blankly at Himmler, who kept silent. When the time came to land, Hitler's pilot…told the Duce landing was not such a good idea. Mussolini turned and saw the convulsed faces of the passengers, who having so far avoided death at the hands of the Soviets did not want to die because of an Italian, however famous he may have been."

Much to Hitler's annoyance, Mussolini then instructed an aide to mention in a joint communiqué from the two Axis leaders that the Duce had flown the Führer home from the front. Mussolini's posturing as an intrepid aviator could have been a scene in a classic movie: Charlie Chaplin's 1940 parody, *The Great Dictator*.

Despite the comic opera aspects of Hitler and Mussolini's aerial odyssey to the Russian front, both men took aviation very seriously. Along with Stalin, the other high-profile authoritarian ruler of the era, they shared an enthusiasm for aviation as a way to showcase national technological progress. Mussolini, Hitler, and Stalin fully comprehended the mystique and powerful public appeal of aviation and exploited the technological marvel of the age—the airplane—for their peculiar ends, including taking to the air themselves.

Hitler and Mussolini (opposite, conversing) flew to the Ukraine in the Immelmann III, *a modified Focke-Wulf Fw 200 Condor airliner (right) and Lufthansa's most advanced transport.*

© CORBIS

Mussolini's rescue: Hitler's commandos flew him from a rough mountain airstrip in a Fieseler Fi 156 Storch.

Mussolini: The Winged Despot

Mussolini displayed a keen interest in aviation as early as 1909, when, as a young socialist and journalist, he had heralded the attempts to fly across the English Channel (with Louis Blériot succeeding) as a portent of the future. He viewed flying machines as more than a novelty or the plaything of the wealthy, arguing that the airplane was destined to alter the course of history.

The stalemate of trench warfare in World War I only deepened his respect for flying. As a soldier, he marveled at the freedom and heroism of pilots, in particular Italy's own Gabriele d'Annunzio, who made a dramatic bombing raid on Austria's capital, Vienna. After the war, Mussolini took great delight in hobnobbing with military pilots, taking airplane rides, and promoting the advance of Italian aviation.

By 1920, Mussolini was ready to take flying lessons. R.J.B. Bosworth's *Mussolini* recounts that he trained at the Arcore airfield, north of Milan, and greatly enjoyed flying, quickly learning rudimentary aerobatics. Soon after completing 18 solo flights, he survived a crash, walking away from the wrecked airplane with only minor scratches on his face and a twisted knee.

The mishap did not slow Mussolini's rise in Italian politics. His stump speeches—delivered in a strutting, highly animated style—attracted a mass following. His muscular physique, truculent jutting jaw, and dark piercing eyes set him apart from other politicians. In 1922, Mussolini gained political control of Italy when his followers, the Blackshirts, made their highly theatrical March on Rome.

Mussolini quickly moved aviation to the forefront of his authoritarian regime. He advocated the building of a modern air force, the Regia Aeronautica, promoted airshows and record-breaking flights, and called for the design of advanced military aircraft. Winning the Schneider Trophy race in 1926 became an early benchmark for Mussolini's air-minded regime. His Minister of Air, Italo Balbo, catapulted Italian aviation to worldwide prominence in 1933 when he led a flotilla of 25 Savoia-Marchetti SM-55 flying boats on a transatlantic flight to New York and Chicago.

Mussolini's stylized reputation as an aviation pioneer meshed well with his larger persona as *Il Duce*, the dynamic leader of Italian Fascism. He appeared in various guises in official propaganda photographs—a sort of Superman at the helm of state, speaking to the masses, playing the violin, singing arias, winning at chess, and, as a man of the people, working shirtless with the peasants at harvest time. Dubbed the First Sportsman of Italy, Mussolini appeared as an avid swimmer, race car driver, equestrian, fencer, and skier. He inspired his countrymen to believe that Italy was on the cusp of greatness—a modern incarnation of the Roman Empire.

The momentum of Mussolini's rise eventually led to military adventures: first the conquest of Ethiopia in 1935 and then intervention in the Spanish Civil War in 1937 to 1939 to support the Nationalists under General Francisco Franco. In the Spanish war, Mussolini's son, Bruno, a pilot, flew 27 combat sorties, and the Italian press lionized him and his fellow airmen as exemplars of Italian aviation under Fascism.

Mussolini cast his lot with Nazi Germany in World War II, committing the Italian military, including the Regia Aeronautica, to a long, ruinous war. Italy now had to contend with the armed forces of Great Britain and the United States, both intent on neutralizing Italian military power in the Mediterranean and seeking unconditional surrender. The stakes could not have been higher: An Allied victory would mean the destruction of Mussolini's regime.

Mussolini's pre-war stress on aerial spectaculars had evoked an image of Italy as a modern air power. In reality, Italy pursued records at the expense of establishing an industrial base for aviation, and the Regia Aeronautica entered the war with few operational aircraft and minimal capacity for reinforcement. When fully mobilized, Italian aviation plants could manufacture only 200 aircraft of various types each month. Great Britain out-produced Italy by more than eight to one; the United States by at least 30 to one. But the airplane would also figure prominently in Mussolini's own fall from power.

Just two weeks after the July 10, 1943 Allied invasion of Sicily, Italy's King Victor Emmanuel III, in league with rebellious elements in the Fascist party, ordered Mussolini's arrest. Once Italy's self-styled "modern-day Roman Caesar," Mussolini began a perilous odyssey. His captors moved

him repeatedly to foil any rescue, finally shipping him to the Apennine Mountains, 80 miles northeast of Rome.

By September, Mussolini was powerless and isolated in a second-floor room at the Campo Imperiale Hotel, atop the Gran Sasso d'Italia. He was keenly aware that any attempt at rescue would be daunting; his resort-prison was on a high plateau accessible only by cable car.

Hitler was greatly alarmed by the arrest of Mussolini, fearing it might set the stage for Italy to pull out of the war and endanger Germany's southern flank. He therefore recruited one of his most talented commandos, Waffen SS Colonel Otto Skorzeny, for a rescue mission, later dubbed Operation Eiche (Oak).

Tall, fearless, and bearing facial scars from 15 duels, Skorzeny was a dedicated Nazi and a soldier tempered by the brutalities of the Russian front; he had all the requisite skills to lead an assault on Gran Sasso d'Italia. On September 12, 1943, he flew out of an airfield near Rome at the leading edge of a group of DFS-230 gliders carrying over 100 commandos.

Mussolini was sitting near a window when he caught sight of Skorzeny's gliders touching down adjacent to the hotel. The commandos quickly advanced and disarmed the guards at the door. Observers later reported that Mussolini had yelled to the Germans from his window, "Don't shoot, don't shed any blood!" Skorzeny himself was the first to reach the second floor, where he disarmed two guards and then burst into Mussolini's room, shouting "Duce, the Führer has sent me. You are free."

Skorzeny had decided to evacuate Mussolini by air, largely because the region surrounding the mountain resort was filled with anti-Fascist partisans. Luftwaffe pilot Walter Gerlach flew a Fiesler Fi 156 Storch to the mountain, landing his short-takeoff-and-landing aircraft on time and in less than one hundred feet.

Skorzeny hurriedly escorted Mussolini to the Storch. For security reasons, Skorzeny decided to fly out with Mussolini, which burdened the aircraft with 220 additional pounds. Mussolini added even more to the Storch's load by insisting on taking all his luggage. Gerlach expressed his apprehension but nevertheless agreed that he would attempt a takeoff.

With the flaps extended and the engine at full throttle, Gerlach took off down the rocky strip. Bouncing along, the Storch slowly gained momentum, then suddenly struck a rock outcropping that smashed the left landing gear. Just as the aircraft cleared the edge of the cliff, Gerlach managed to regain control and set a course for Rome. From there, the Luftwaffe flew Mussolini to Vienna and then Rastenburg in East Prussia, where he was reunited with Adolf Hitler.

Despite his remarkable rescue by Hitler, Mussolini proved to be a reluctant and ineffectual ally. He agreed to head up a short-lived puppet regime in northern Italy, proclaimed as the new Italian Social Republic, but his heart was not in it. The war had been difficult for Mussolini and filled with tragic events, not the least being the death of Bruno while testing a new bomber.

On April 27, 1945, Benito Mussolini, along with his mistress, Clara Petacci, was captured by Italian partisans and summarily executed.

Hitler: The Pioneer of "Luftwaffe One"

In the opening frames of Leni Riefenstahl's propaganda film *Triumph des Willens* (Triumph of the Will), Adolf Hitler appears in the skies over Nuremberg in a glistening Junkers Ju 52; its shadow is shown moving across the cityscape. The event is the 1934 Reich's Party Day convention, and the crowds milling in the streets below glance skyward to follow the Junkers. They greet the arrival of Hitler with awe and anticipation. The symbolism was powerful: The new German Führer, descending from the heavens, embodied the vision of German renewal.

During his 12 years in power, Hitler proved to be a frequent flier. And he managed to pioneer some real innovations, among them the first air squadron to operate a head of state's aircraft—an analog of the U.S. Air Force's 89th Airlift Wing, which operates Air Force One. He also fully embraced aviation as essential for the evolution of national life and as a way to project military power.

Unlike Mussolini, Hitler took no particular delight in flying and was not interested in learning to fly. His approach was measured, more an embrace of necessity than a personal passion. Hitler's involvement began in the national elections


MINISTERO DELL'AERONAUTICA

Verbale di nomina a Pilota Militare di Aeroplano del S. E. Benito Mussolini

LA SOTTONOTATA COMMISSIONE

CONSTATATO che il S. E. Benito Mussolini

ha svolto il prescritto numero di ore di volo ed altresì eseguite le seguenti prove previste dal regolamento

— estrata in campo con volo librato continuo da m. 1500 (rettangolo);
— salita alla quota di m. 3 500;
— otto in volo (5 circuiti in forma di otto alla quota di m. 600)

DICHIARA

che il S. E. Benito Mussolini

ha conseguito l'idoneità per la nomina a pilota militare di apparecchio S. 81

il 12 Gennaio 1937-XV

Roma, il 12 Gennaio 1937-XV.

LA COMMISSIONE

COURTESY OF VON HARDESTY/NASM (2)

Mussolini's pre-war stress on aerial spectaculars had evoked an image of Italy as a modern air power. In reality, Italy pursued records at the expense of establishing an industrial base for aviation, and the Regia Aeronautica entered the war with few operational aircraft.

Mussolini (above) had a civilian pilot's license but never flew in combat. His son flew in the Spanish Civil War but died on a test flight.

© CORBIS

Hitler rode a chartered Lufthansa Ju 52 during political campaigns. The German leader later organized the first military flying unit dedicated to serving a chief of state.

of 1932, when as a presidential candidate of the National Socialist Workers Party, he leased a tri-motor Junkers Ju 52 transport from Lufthansa German Airlines for campaign jaunts.

Hans Baur, a veteran flier of World War I and a senior Lufthansa pilot, accepted the charter assignment. Baur flew Hitler to a number of rallies, fostering in the Nazi leader a level of comfort with air travel. When Hitler became chancellor in 1933, he formed the Fliegerstaffel des Führers, or F.d.F. (Aviation Squadron of the Leader), with Baur in charge as his personal pilot. The F.d.F. operated independently of the Luftwaffe and reported directly to Hitler.

Based at Berlin's Tempelhof airport, the squadron quickly expanded. Baur attracted the most talented pilots and technicians, creating an elite unit. Since Hitler flew only occasionally, the squadron began to transport other Nazi leaders: Heinrich Himmler, Herman Goering, Karl Doenitz, and Albert Speer. Baur's unit also flew Hitler's Axis partners to Germany: Mussolini was a frequent passenger, as was Ion Antonescu of Romania, Miklos von Horthy of Hungary, and King Boris of Bulgaria.

After several years of flying the Junkers Ju 52, the squadron happily made the transition to the new Focke-Wulf Fw 200 Condor in 1939. The Condors represented a new level of technology and comfort. Hitler's personal Fw 200, christened the *Immelmann III*, entered service in late 1939.

Hitler's Condor was highly modified: The interior of the fuselage was divided into two compartments, the forward compartment for the Führer, the aft section for staff and guests. Hitler's compartment was fitted with a couch, a table, the *Führersessel* seat, and an altimeter, airspeed indicator, and clock.

During the war, the F.d.F. added an armed Fw 200 Condor that had been a maritime reconnaissance bomber. Bristling with gun turrets, the airplane had a cabin identical to that of the *Immelmann III* except that Hitler's special seat was armor-plated and fitted with a parachute. A safe was installed for important documents and personal items. The airplane also had a lavatory and a small galley with a cupboard full of elegant china, crystal, and silverware, all adorned with the eagle and swastika.

The F.d.F. flew 13 armed Condors during World War II. For Hitler and his advisers, these special aircraft became an essential link to the outside world. To better match Hitler's pattern of travel, the F.d.F. established a new airfield close to his headquarters: the *Wolfsschanze* (Wolf's Lair) at Rastenburg in East Prussia.

High security surrounded all flights of Hitler's Condor during the war. This security screen was broken in 1943 when two talented German officers, Major General Henning von Tresckow and his close aide, Lieutenant Fabian von Schlabrendorff, fashioned a bizarre plot. Both men were part of a loose network of officers seeking to topple the regime. After the defeat of the German army at Stalingrad, these officers believed the only way to reverse the disastrous course of the war was to eliminate Hitler. Calling their plan Operation Flash, the conspirators plotted to place a time bomb on the *Immelmann III* when Hitler made a scheduled flight to Smolensk in March 1943.

Getting close to the Führer was no easy task. Hitler flew only occasionally to the front and often changed his itinerary with no advance notice. Security measures, routinely severe, were heightened whenever Hitler was on board. The airplane was always guarded by SS troops and escorted to its destination by a flotilla of fighters. Hitler also flew in the secure knowledge that his *Führersessel* sat atop an escape hatch through which he could theoretically parachute to safety.

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Finding a suitable bomb posed another problem; existing German fuses emitted a hissing sound. The conspirators turned to Admiral Wilhelm Canaris, head of Abwehr (German intelligence) and sympathetic to their cause. Canaris made available to Treschow several captured British bombs with great explosive power and silent fuses. Always thorough, Treschow tested several samples of the devices even as he studied purloined sketches of the aircraft's interior. Meanwhile Schlabrendorff cleverly fashioned the bomb to fit into what looked like a package containing two brandy bottles.

On the morning of March 14, 1943, the plotters were ready to act. Treschow asked Colonel Heinz Brandt, a member of Hitler's official party, if he would

deliver a gift to General Helmuth Stieff, a mutual acquaintance. Brandt innocently agreed, never realizing that he would be putting his own life in jeopardy. Treschow and Schlabrendorff delivered the potent explosive package to Brandt at the airfield, and just before Schlabrendorff gave Brandt the package, he pressed on the package and crushed a vial filled with acid, which began to dissolve a wire holding the striker mechanism in place. The bomb was timed to explode in 30 minutes, about the time Hitler would be over Minsk.

Treschow and Schlabrendorff returned to their offices confident that a fiery crash would eliminate Hitler. Hours passed before reports arrived that Hitler had landed safely in Rastenburg. Schlabrendorff then made an arduous journey to retrieve the bomb from Brandt, telling him that Treschow had mistakenly given him the wrong bottles. Later, Schlabrendorff discovered that the striker mechanism had released properly, but the bomb had failed to detonate, probably because of the low temperature in the cargo hold. Although he never realized it, Hitler had survived his most perilous air journey.

Stalin's Fear of Flying

Soviet ruler Joseph Stalin commuted from his dacha in the suburbs of Moscow to his office in the Kremlin in a heavily guarded motorcade. For rare travel beyond Moscow, he typically used an armored train with a large contingent of soldiers. He harbored a deep fear of flying and flew only once, to attend the 1943 Tehran conference with British Prime Minister Winston Churchill and President Franklin Roosevelt.

Stalin hid his disinclination to fly behind a facade of air enthusiasm: In this cardboard reality he was a patron of airshows, the builder of a mighty air force, and the inspired genius behind Soviet air triumphs in the pre-war years. He basked in the accomplishments of his elite pilots, Stalin's Falcons, and his name was emblazoned on Valery Chkalov's ANT-25 airplane as it made a flight across the North Pole in 1937. At Stalin's behest, Soviet aircraft flew against Franco's rebels in the Spanish Civil War, and on the eve of World War II, the Soviet Union boasted a force of 10,000 aircraft.

To the citizenry, Stalin was remote and godlike—the audacious revolutionary and heir to Lenin, a brilliant prophet of Communism, great teacher, and kindly and infallible father of the nation. Yet he presided over the great purges of the late 1930s. Arrests, show trials, and a vast system of prisons and labor camps reflected his fear that enemies were poised to overthrow his regime.

Stalin lived a cloistered and secretive life, always fearing conspiracy. He was a night owl who obliged party and government officials to remain close to their phones at all hours in anticipation of a call. Many contemporaries described Stalin's eyes as yellow and alert, like a tiger's. His short stature, pockmarked face, and withered arm had not slowed his advance to absolute political power. He did not drink to excess, but he was an inveterate chain smoker, known to Americans in World War II as the benign, pipe-smoking "Uncle Joe."

To Stalin, every failure was a sign that the enemies of the people were at work. A tragic crash of the giant Tupolev ANT-20 transport raised the specter of sab-

The Maxim Gorky, *an enormous eight-engine Tupolev ANT-20 (right), struck awe in those who watched its propaganda flights over Red Square (below). The lumbering monster crashed when one of its escorts plunged into it during an impromptu stunt, killing all on board.*

COURTESY OF VON HARDESTY/NASM (2)

otage carried out by hostile elements.

The eight-engine aircraft, named the *Maxim Gorky*, was built in 1934 and made dramatic flyovers of Red Square. Passengers enjoyed bourgeois comforts: easy chairs, reading lamps, sleeping berths, a galley, and even a library. With onboard cinema, loudspeakers, and a print shop, the airplane became flying proof that the Soviets were at the cutting edge of aeronautical technology. Rides on the *Maxim Gorky* were reserved for the party elite and those factory and farm laborers who had dramatically exceeded their work quotas.

The *Maxim Gorky* came to an abrupt end on May 18, 1935, when Nikolai Blagin, performing aerobatic maneuvers in an I-5 biplane escort, crashed into its right wing. The lumbering airplane shook upon impact, continued on briefly, and crashed. The accident killed Blagin and 49 others, and cast a pall over Soviet aviation at the very time Stalin was vying with European powers for air records. No doubt this tragedy added to Stalin's personal fear of flying.

Nonetheless, in 1943 Stalin was compelled to attend the Allied conference in Tehran with Winston Churchill and Franklin D. Roosevelt. The earth-bound Stalin would have preferred an overland trip to Iran, but no secure or practical rail link existed, and he reluctantly agreed to fly.

Two Soviet versions of the Douglas DC-3 airliner, built under license as the Li-2, had been specially configured for the flight. Always suspicious, Stalin rejected the two aircraft in favor of two American-built Lend-Lease C-47 transports drawn from active service in the Soviet air force.

For the mission, the air force's Supreme Command took special care to test and service the two aircraft. Air Commander Alexander Novikov then ordered the two C-47s flown to Baku, the departure point.

On November 27, 1943, Stalin arrived at the airfield to face the dilemma of which C-47 transport to board for Tehran. Air Marshal Alexander Golovanov, commander of the 18th Air Army (strategic aviation), had been designated Stalin's pilot, a logical choice. The second C-47 was to be flown by a relative unknown, Lieutenant Colonel M. Grachev, a pilot pulled from frontline duty.

The moment of truth came as Stalin approached Golovanov's C-47, the airplane designated for him. He paused, and glanced over his shoulder at the second C-47. Then he announced: "So, who will we fly with? Perhaps it is better to go with Grachev. Marshals do more sitting behind a desk than behind the controls of a plane. It will be safer that way!"

Grachev flew Stalin without mishap, for which he received a warm handshake from Stalin, a quick promotion in rank, and later, the highest military honor: Hero of the Soviet Union. However, rumors circulated that Stalin's C-47 had encountered severe turbulence en route. Passengers on board reported that Stalin had been terrified by the bumpy ride and was visibly tense. After this journey, he never flew again.

Despite Stalin's phobia, the Soviet air force command established a special air regiment for use by the Soviet brass. A parallel unit for Soviet dignitaries was organized under the control of the NKVD, or secret police. These units, made operational in 1944, represented a radical departure from the past, offering luxury air travel for the political elite.

Unit planners chose as their aircraft the Pe-8 (TB-7) bomber, a Soviet four-engine type built in small numbers during the war. The Pe-8 fitted for VIP passenger service—the "Ye" model—could carry 14 people in some comfort, despite wartime shortages in lightweight metals and the absence of materials for upholstery. The interior fuselage was laid out like that of a pre-war DC-3 airliner: It had two rows of cushioned seats with overhead luggage racks and sleeping berths. Soundproof bulkheads, a toilet, hot water, oxygen masks, and lights for each seat gave this

BELOW: COURTESY OF VON HARDESTY/NASM; RIGHT: NATIONAL ARCHIVES

Joseph Stalin (seated, right, at Yalta), made only one flight to meet Churchill and Roosevelt: His air trip to Tehran in 1943 was his last, and thereafter his two allies had to come to him. In 1942, a converted Petlyakov Pe-8 bomber (below) flew Soviet diplomats to Bolling Airfield, in Washington, D.C.

Stalin used a U.S.-built Lend-lease C-47 (right) for his Tehran trip. Above: A postcard shows that aviation was a powerful symbol for the Soviets.

Rumors circulated that Stalin's C-47 had encountered severe turbulence en route. Passengers on board reported that Stalin had been terrified by the bumpy ride and was visibly tense.

COURTESY OF VON HARDESTY/NASM (2)

Pe-8 an unaccustomed level of luxury.

Stalin's unspoken "no fly" policy shaped the character of wartime diplomacy in subtle ways, often frustrating and inconveniencing Churchill and Roosevelt. Churchill flew to Moscow in October 1944 for a critical meeting with Stalin. The ailing Roosevelt, just two months prior to his death, made an arduous journey by sea and air to Yalta in the Crimea in 1945 for the last Big Three meeting of the Allied leaders. The alternative of asking Stalin to fly to a neutral site was never seriously considered.

Though he shunned flying, Stalin was most willing to send his minions on dangerous wartime air missions. Foreign Minister Vyacheslav M. Molotov flew on a Pe-8 from Moscow to Washington D.C.'s Bolling Airfield in May 1942. Dressed in a fur-lined flying suit and boots, Molotov endured the journey in an unheated cabin. He and his delegation were keenly aware of the dangers of crossing the north Atlantic twice with no effective survival equipment on board.

In late summer 1944, Andrei Gromyko, a senior Soviet diplomat, substituted for Stalin on one of the most bizarre Soviet diplomatic forays of the war. He led a 19-member delegation to Washington, D.C., for the Dumbarton Oaks conference to establish the United Nations.

Assigned a marginally flyable C-47, Gromyko flew from Moscow across the vast expanse of Siberia to Fairbanks, Alaska. Upon reaching Fairbanks, three U.S. airmen boarded Gromyko's airplane to organize a mixed American-Russian cockpit crew for the final leg to Washington. Gromyko insisted that the command seat on the left be reserved for the Soviet pilot, who did not speak English.

The American pilot assigned to the flight was shocked that one of the Soviet Union's top diplomats was flying on such a derelict aircraft. Moreover, he angrily protested having to take the copilot's seat.

David Chavchavadze, an Army Air Forces lieutenant, served as the interpreter during the tension-filled flight across Canada and the United States, standing between the Soviet and American pilots in the cockpit. Chavchavadze later reported that the disgruntled and nervous American pilot began each communication to his Soviet counterpart in the left seat with "Tell that son of a bitch...." Even when he was confronted with unfamiliar flight protocols and landing procedures, the Soviet pilot refused to surrender the controls, telling his copilot: "In the Soviet Union we learn quickly."

Luckily, good weather allowed for a safe passage to Washington. On the return trip, however, the Gromyko transport limped into Edmonton, Alberta, broke down, and was declared unfit to fly. The United States provided a replacement airplane.

When Stalin traveled to Potsdam for the July 1945 conference, he chose a special train made up of 11 armored coaches with more than 17,000 NKVD troops to provide security. Stalin himself traveled in any of four green carriages, former tsarist cars removed from a museum. As the train approached Germany, the number of guards deployed to protect the tracks increased from six men per kilometer in Russia to 10 per kilometer in Poland to 15 per kilometer outside Potsdam in occupied Germany.

While 11 aircraft were ready to handle any urgent requirement to evacuate Stalin and his delegation from Potsdam, it was apparent that Stalin would never fly. Nonetheless, he continued to promote aviation, building the intercontinental Tu-4 bomber and fostering jet technology for his air force and for the fledgling Aeroflot airline. To the very end, Soviet propaganda organs portrayed him as the great prophet of aviation progress.

Stalin died in March 1953, and six years later, his political heir, Nikita Khrushchev, flew in a huge Tu-114 turboprop airliner to Washington, D.C. for a Cold war conclave with President Dwight Eisenhower. He appeared to enjoy the flight.

COMET CRACKER

A SUMMER SPACE MISSION HAS A SIMPLE PLAN:
LAUNCH. CRASH. WATCH.

BY TONY REICHHARDT

MIKE A'HEARN THINKS BINOCULARS should be enough. When his 800-pound, copper-tipped spacecraft collides at six miles a second with an unsuspecting comet called Tempel 1 in July, no one, not even A'Hearn, knows exactly what will happen. There almost certainly will be a smash, and a splash, and a flash, as tons of icy grit freed from the heart of the comet spray outward into sunlight. The whole drama, he reckons, shouldn't take more than 800 seconds. A'Hearn expects the brightening will be visible on Earth with a small telescope or binoculars, perhaps even the naked eye, and that millions of people will be watching. God knows he will. So will half the telescopes on Earth, amateur and professional alike.

Closer to the action, the impactor's mothership will be observing with its cameras and spectrometers from a safe distance of 310 miles, having separated and veered off from the smaller impactor 24 hours earlier. A'Hearn, a planetary scientist at the University of Maryland, and the rest of the team that designed the mission, which they call Deep Impact, could have placed the mothership even closer. But they chose the distance partly to protect it from dust impacts and partly to ensure that the instruments take in everything that comes flying out from the comet.

There are many ways to study comets, and scientists have tried most of them. The U.S.-European Solar and Heliospheric Observatory—SOHO—routinely watches comets fall into the sun from its vantage point a million miles from Earth. In the 1980s, European, Russian, and Japanese spacecraft flew close to Halley's Comet, taking pictures and sampling the dust and gas boiling off the nucleus as the comet rounded the sun. Deep Space 1 visited Comet Borrelly in 2001, and

OPPOSITE INSET: EUROPEAN SPACE AGENCY

COURTESY BALL AEROSPACE AND TECHNOLOGIES CORP.

Mike A'Hearn's spacecraft will be the first to make contact with a comet. By contrast, the 1986 Giotto got only within snapshot range of Halley's Comet (opposite).

Stardust came within 149 miles of Comet Wild 2 last year, grabbing dust samples that will return to Earth next January.

Deep Impact will be the first spacecraft to crack open a comet's nucleus to see what's inside. But if that makes it sound all big and bad, it's not. The comet runs into the spacecraft, not the other way around. The TV-size impactor will wait in Tempel 1's path like a bug on a highway, and when the four-mile-wide comet comes crashing into it, the spacecraft will vaporize instantly. Then, if all goes as planned, a 100- to 150-foot-deep crater will form, exposing the comet's pristine interior—material that has been sealed up since it formed at the edge of the solar system billions of years ago. For A'Hearn and his team, this is the payoff of the mission: finding out precisely which elements make up Tempel 1's nucleus.

As appealing as most people find the idea of smashing up a multimillion-dollar spacecraft, A'Hearn says that when the impactor was first proposed more than a decade ago, "the instinctive reaction was 'That's dumb—why would you want to do that?' " In fact, there's no better way to see deep inside a comet; no present drill could go into space and make a hole that deep. Anyway, the destructive element never bothered A'Hearn: "If you think about what you know and what you don't know, this is a way to find out things you don't know."

This isn't just fun, people. It's science.

Peter Schultz, a co-investigator for Deep Impact, has spent much of his career thinking about the physics of cratering. As a planetary geologist at Brown University in Rhode Island, he has investigated impact sites from Argentina to Canada, trying to reconstruct in detail what happens when a small body like an asteroid slams into a planet at ten times the speed of a rifle bullet. To predict the effect of Deep Impact's collision, he's been making his own craters at the Vertical Gun Range at NASA's Ames Research Center near San Francisco. There, inside a bland, industrial-looking building, he shoots at different target materials with projectiles traveling at velocities up to four miles per second—not as fast as Tempel 1 will be moving, but fast enough so the results can be used to predict what might happen to the comet.

Schultz has experimented with pumice, a lightweight volcanic rock, as the target. He's also tried pumice dust. He's used perlite, a crushed rock

commonly found in gardens; perlite with ice; and silica microbeads, the material used to make stop signs reflective. He varies the speed and angle of impact; he varies the porosity and density of the target. He's done hundreds of test firings to master the nuances of cratering.

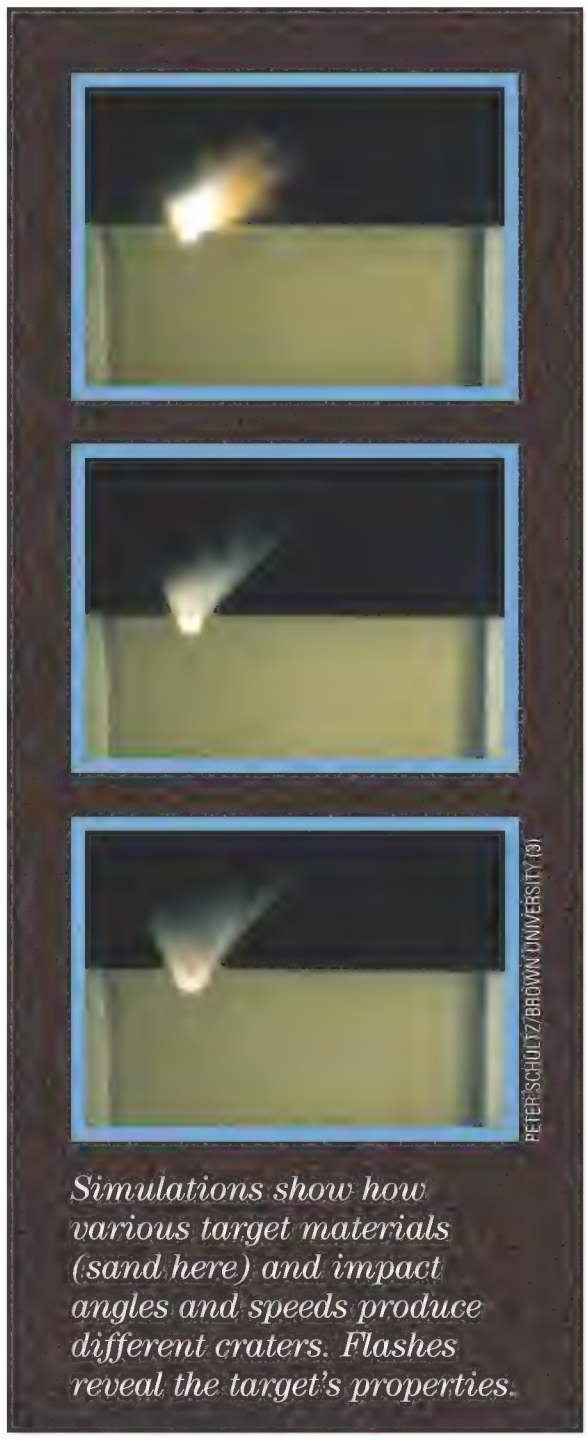
Comet nuclei are not easy to imagine. Having seen pictures of what look like solid objects, we think of them as rocks. But some, says Schultz, may be as fluffy as cotton candy. A'Hearn likens their insides to "very good powder snow for skiing." The degree of fluffiness, porosity, lumpiness or smoothness—all these factors affect how deep a crater will form, and what shape it will take.

The speed of the impactor also makes a difference. If you stood over a deep pile of pumice dust, the kind Schultz sometimes uses to simulate cometary material, and dropped a metal rod pointing down into the pile, the rod would fall straight through. But at four miles a second, a rounded impactor forms a crater instead, shattering and melting in the process.

In one of Schultz's scenarios for Deep Impact—the most likely one, he thinks—material will spray out from the crater in a nice conical pattern. In others it also shoots straight back out the hole like sparks from a Roman candle. Some scenarios have the impactor getting embedded in the comet, and in one it goes right through the nucleus and comes out the other side. The last outcome, says Schultz, is so improbable that it is mentioned "almost tongue-in-cheek. But it shows you what we know about comets."

Schultz conducts his gun tests with a projectile made of Pyrex; that material shatters at the slower velocity of the simulations, just as the copper impactor will shatter when Tempel 1 hits it at a higher speed. When A'Hearn first started working on Deep Impact, some people, no doubt hoping for the biggest possible boom, suggested the impactor be made of the heaviest materials they could think of, including uranium. But to dig a crater most effectively, says A'Hearn, you really want something about the same density as the comet. In fact, the engineers have carved little pockets from the copper projectile to reduce its density in order to more closely match the density estimated for Tempel 1.

And because the projectile will vaporize on impact, it has to be made of an element that won't chemically combine with water from the comet, confusing the spectrometer readings taken by the mothership. That requirement ruled out aluminum, for example. Ball



Simulations show how various target materials (sand here) and impact angles and speeds produce different craters. Flashes reveal the target's properties.

Aerospace, which built the spacecraft, had gotten a good deal on electronics boxes made of magnesium, but A'Hearn had to nix that deal. The best materials turned out to be noble metals, like gold, silver, platinum, and copper. Having only $267 million to spend on their mission, the team went with copper.

Whatever transpires when copper strikes comet, it will happen in slow motion. When an asteroid smashes into Earth, a crater forms in a few seconds of unimaginable violence. On a tiny comet nucleus, with its extremely weak gravity—you could jump off the surface and never come back down—you'd expect the explosion to go faster. But exactly the opposite happens. "It is very counterintuitive, and it took me a long time to think my way through it," says A'Hearn. Right after impact, displaced material starts coming out from the interior. The more time passes, the slower the material exits. The crater stops growing only when the stuff from the interior is moving so slowly that gravity pulls it back before it reaches the rim. But in low gravity, even stuff moving very slowly can make it to the rim, so the whole process takes longer.

Schultz predicts that Deep Impact's crater will take 200 seconds to form, maybe longer, though not more than 500 seconds. To give themselves some margin, the science team has planned to have the mothership's cameras and spectrometers observe closely for 800 seconds. "We don't want to fly by until it's all over," says A'Hearn.

Low gravity also makes the crater end up much bigger. If the Deep Impact projectile hit an airless body with the mass of Earth, it would gouge a hole maybe 20 feet wide. Schultz thinks the hole in the comet nucleus will be 10 or even 20 times larger.

The drama may not end with cratering. One important question about comets, particularly old ones like Tempel 1, is whether centuries of swinging in toward the sun has caused their volatile components, like water, to have boiled away. If not, reservoirs may be bottled up inside that will vent once the hard crust is breached. If Deep Impact opens such a vent, says A'Hearn, "my guess is that it will come within minutes. It could certainly be hours. Days I think is unlikely."

The venting could be violent, with large jets of gas spewing into space. And if the nucleus contains lots of water vapor, Schultz says, "we may cause an explosion inside the comet," one powerful enough to break Tempel 1 apart. That's unlikely, says Schultz,

"but as an experimentalist, you never say never."

Some of Schultz's simulations show big plates of crust flying off after the impact. By tracing the ballistic arc of the plates, the scientists could determine the comet's gravity, and therefore its mass—a fundamental property that has never been measured for a comet.

During and after the explosion, the mothership's cameras and spectrometers will be busily scanning the crater and the icy dust that comes flying out. The pristine material A'Hearn hopes to see—ices that haven't been crunched, melted, or altered by sunlight since they first formed—could be dozens of feet deep, or right below the surface. The important clues about the early solar system will be the relative abundances of water, carbon monoxide, and carbon dioxide. From the proportions, the scientists will be able to deduce the temperature at which the compounds formed. That in turn will help them understand the conditions under which the solar system was created.

Another uncertainty is driving the scientists crazy: They don't know the exact shape of the elongated comet nucleus—where it bulges and where it's thinner. And the uncertainty makes navigating Deep Impact trickier.

Because the orbit of Tempel 1 is well known, the team will be able to put the craft on a trajectory that comes reasonably close to the comet. But to ensure that it actually makes contact, the impactor will, in the last 24 hours of its journey, rely on onboard software that makes small course corrections based on images the probe takes as it closes in. The navigation system will direct the craft's hydrazine thrusters to guide Deep Impact to the brightest area on the comet. But if the slowly turning comet is shaped like a dumbbell, its brightness will be constantly changing, and that could fool the system into charting a course that misses the comet completely. The team has been tweaking the software to account for the uncertainty, though, and A'Hearn is now "99 percent confident" that the craft will hit the target.

The world will be watching. Most big observatories in Hawaii, like the twin Keck Telescopes on Mauna Kea, will be trained on Tempel 1 at the critical moment. A'Hearn and some of the team members will watch from the Jet Propulsion Laboratory in Pasadena, California, where Deep Impact's data will be received. They will all be anxious to see if years of work will produce 13-plus minutes of unique data. If the team pulls it off, Deep Impact will make humanity's first direct contact with a comet nucleus.

Did we mention that all the fireworks take place on the 4th of July? A perfect date for making history.

PAT RAWLINGS/NASA

The Deep Impact mothership will capture information on the comet's freshly exposed primordial interior.

Red Bull

Catch a thrill

One by one the racers charge the course. They dash and dance through a prescribed sequence—climbing corkscrews, knife-edge passes, precise rolls—all racing the clock through an obstacle course of 50-foot-high inflatable gates. The performance is mesmerizing and utterly alien to the hundreds of fans drawn year after year to the National Championship Air Races in Reno, Nevada.

Fans have come to Reno since 1964 for the World War II charisma of piston-powered racers that roar, six to a heat, around fixed, lethal-if-struck pylons at 500 mph. Last September, the fans got that hit of adrenaline—and they were introduced to the other race. One has guts and thunder; the other, grace and cunning. One is homegrown and flown in a pack; the other is a European import and solitary. The question before the Reno Air Racing Association last year was: Is there room in this town for both?

Shortly before last year's races, RARA president and CEO Mike Houghton seemed to think so. "It appears to have an enormous amount of fan appeal and excitement," he said of the aerobatic race sponsored by Red Bull, the Austrian energy drink company.

′s Rodeo

Air races may never be the same.

by Larry Lowe

JAMES LAWRENCE (2)

In an Edge 540, Kirby Chambliss had racked up two Red Bull Air Race wins before he rocketed through the gates in Reno last September, competing for the world cup. Red Bull staged three international races in 2004 to market its energy drink.

"Each aircraft has a wingtip cam, a tail cam, and a cockpit cam. They will be doing live broadcasts on three huge screens in front of our crowd."

But first, the U.S. Federal Aviation Administration had to decide if the Red Bull Air Race could be flown in U.S. airspace.

The prime directive of FAA airshow operations is that no airplane will have its energy directed toward the crowd during an aerobatic maneuver. The rule is intended to prevent gasoline or chunks of airplane from being hurled at spectators should a pilot lose control of the aircraft. Red Bull's race course has pilots turning airplanes every

which way while careening through five slalom gates. So Reno vice chairman Tom Gribbin, with help from aerobatic competitors Mike Goulian and Kirby Chambliss, rearranged the route through the five paired pylons so that all hard turns would be flown away from the crowd.

Susan Gardner, the FAA's national airshow coordinator last fall, was responsible for approving the event. "My first reaction was that it was incredibly exciting, number one, and different," she said, but she also thought, "Oh! Well. We can't do some of these things here." She continued, "We have pretty stringent criteria when you compare America to many other countries." Criteria that preclude, for example, flying under a 25-foot-high stone bridge to start and finish a race—as the pilots did in Budapest last August.

But Gardner approved a demonstration, and the pilots took the stage. Eight pilots, selected by Red Bull to compete because of their experience in competition aerobatics and low-altitude airshow performances, used the early part of race week at Reno to learn the course.

Peter Besenyei is a craggy-faced Hungarian airshow star, an aerobatic champion who pitched the concept of an aerobatic race to Red Bull. "Our idea was to create something new in aviation sports, something colorful, something exacting," he said. "It's also very spectacular, because we are flying low, we are flying fast, we are flying between the gates."

Besenyei is quiet; among the other aerobatic performers, he often disappears into the background. But in an airplane, he is a wild man. At dawn on Wednesday, when the pilots were presenting the dress rehearsal to Gardner, Besenyei made one of the most memorable flights of the event. From the judging stand, his Edge 540T appeared mostly in silhouette against the pale sky: a dancer spinning against the purple of a horizon that faded upward to light blue. His performance was flawless.

Four-time U.S. Aerobatic Champion Kirby Chambliss was in Reno to claim another title, having won both previous 2004 Red Bull events (in Hungary and England). Among those following the series, it was a foregone conclusion that Chambliss would take the 2004 Red Bull World Championship, which was at stake in Reno, unless he made a mistake that let Besenyei slip past him. What everyone else was racing for was third.

The British were represented by Sukhoi Su-31 pilots Steve Jones and Paul Bonhomme, an airshow duo known as the Matadors and more accustomed to performing in practiced synchrony than to competing against each other. Their airshow act does not include, for example, anything like the sequence that must be flown at the finish of the Red Bull race: After executing

On Reno's hallowed ground (below), Red Bull deployed dashing new racers and elegant graphics. The "energy" aesthetic extended to a hospitality center (right), where brainstormers rubbed elbows with champions (left to right: course designers Martin Jehart and Peter Besenyei; pilots Mike Mangold and Kirby Chambliss).

CAROLINE SHEEN (2)

two points of a four-point roll on a vertical line begun at ground level, the pilot must fly a half inside or outside loop to point the airplane, at 800 or 900 feet, straight down, from which attitude the pilot then does a touch-and-go, putting the main gear down on a chalked Red Bull logo, about 20 feet

Race director Hannes Arch (at right) congratulated come-from-behinder Mike Mangold. The exacting David Martin was at the top of his game in the Breitling Cap 232 (left), but his perfect flight was too slow to qualify for the final competition.

LEFT: CHRISTIAN PONDELLA; ABOVE: CAROLINE SHEEN

square and 680 feet from the reserve seat grandstands (see diagram, p. 45).

Paul Bonhomme admitted that the demanding sequences were "quite close" to the edge of what was sensible for airplane and pilot. "But I think that's what makes it exciting," he said. "And I think the good thing about the guys doing this is that they're all old and ugly enough to know when to back off. At the end of the day, what you want is Sunday afternoon everyone grabbing a cold beer saying, 'What a good laugh that was!' "

At Reno, more than at the previous racing venues, the pilots had to remind themselves that discretion is the better part of valor. Reno is at an elevation of 5,046 feet, but the density altitude—the effective operating altitude, taking into account temperature, barometric pressure, and humidity—can be

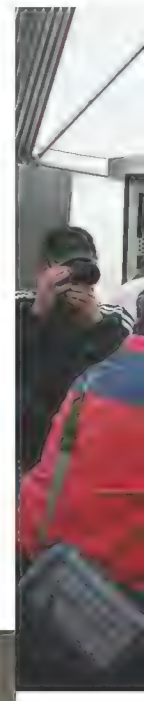
Sukhoi Su-31 pilot Steve Jones nailed the knife-edge pass through gate number three.

over 8,000 feet. At that altitude, an engine produces only 80 percent of its rated horsepower.

To give the pilots a chance to practice their chops in Reno conditions, Red Bull set up an aerobatic box and some inflatable gates at Beckwourth, a reliever field to the northwest of the racing grounds. There Mike Mangold, an F-4 Phantom pilot turned 767 captain and aerobatic champ, ran through the two-point-of-four vertical roll to the touch-and-go sequence no less than 15 times, trying to determine both the proper strategy for the stunt and the feel of the airplane when he got it right. Throughout the days of practice, the pilots discussed two theories. One says you slow the airplane down and get really good at hitting the target, assuming that the two or three extra seconds required to set up the approach carefully will be fewer than the five penalty seconds added to your time if you miss the target altogether. The other says you race through the figure, put the gear on the ground as best you can at speed, and accept any penalty you might incur as the price paid for keeping your energy up. Surprisingly, Mangold, the hard charger, decided to slow for an attempt at a no-penalty touch.

The pilots weren't the only ones who had to practice. On Wednesday morning while the airport slept, Red Bull manager of race operations Hannes Arch had over a dozen pickup trucks assembled at the staging area near the Red Bull chalet. The drivers of the pickups were about to practice the rapid deployment of the inflatable race course, what Reno's Tom Gribbin called "the running of the bulls." Because of Reno's tight show schedule, Arch needed to assure himself that in less than three minutes from a standing start, he could deploy the ground crew and video team, inflate the pylons, position the judges, erect the starting flags, and clear the aerobatic box.

When the radio crackled with the go signal, the convoy moved out in double time. In minutes, all was in place except the start/finish flag. As the flag unfurled, Arch



LEFT: CHRISTIAN PONDELLA; BELOW: CAROLINE SHEEN

Martin Jehart (below) rested on his laurels, the uninflated pylons he engineered. In a Red Bull-sponsored play station packed with video games (right), Peter Besenyei signed autographs.

called over the radio to the crew to put everything back to the start line. Not fast enough. One more time.

The three-person judging team, led by former U.S. World Aerobatic Team judge Alan Geringer, was stationed on a long, raised platform set up near the home pylon of Reno's traditional race course, on the opposite side of the aerobatic display box from the grandstand. From that vantage point, the judges observed the race and monitored the pilots for infractions, such as passing through the gates higher than, instead of below, the tops.

During the rehearsal, Kirby Chambliss

LEFT: CAROLINE SHEEN; ABOVE: JAMES LAWRENCE

dragged a wingtip through a pylon in gate three, but the touch was so deft that the judging crew didn't notice it at first. It was no accident. Chambliss had acquired more time flying through this configuration of gates than anyone at the airport. He nipped the pylon at the request of Sue Gardner, who was in the audience with the media, watching this full dress rehearsal to decide whether to let the guys do their thing in front of spectators. She wanted to see how the Red Bull team would handle a busted pylon, so Chambliss broke one for her.

As soon as Chambliss exited the course, the pylon replacement crew rushed in while the next racer was held on the end of the runway. In six minutes, they had removed the deflated pylon, uncovered and inflated the reserve, and cleared the course—a performance that satisfied Gardner that the team could recover from a pylon cut quickly without having people and raceplanes on the course at the same time.

Later in the rehearsal, however, the driver of a Red Bull pickup truck thought he heard an order to proceed, and he drove across an active runway. Fearing a language barrier, the Austrian Hannes Arch and American pilot manager Sterling Price worked for three hours that day to draft a line-by-line script to follow so that Arch could monitor Price's air traffic control and manage the supporting vehicles of the race accordingly.

Despite the runway incursion, Gardner approved the Red Bull Air Race for exactly one public performance on Thursday. Keeping the Austrian air circus on a tight leash, she wanted to watch the first heat before deciding if the team should be allowed to operate the remaining three days under the RARA's mentorship.

Overnight, all of the pilots seemed to settle into the rhythm of the course, and the race went off without a hitch. Satisfied that the race design and operations were sound, Gardner signed off on a waiver that allowed the remaining three races to proceed.

Whether it was the focused practicing, the

Culture clash? On the Reno ramp, two Cap 232s faced off with racing's rugged mainstay: the P-51 Mustang (seen through the Cap's canopy).

Red Bull Air Race Course

The Finish: *After gate 7, the racers pulled into a two-point-of-four vertical roll, followed with a half loop to point straight down, executed a touch-and-go (8), and arced around through gate 9.*

To hype the brand and the event, pilots Kirby Chambliss and Mike Mangold in Edge 540s (foreground) and David Martin in the Cap 232 flew formation on media day. (On race day, the Edges had the edge.)

need to convince Gardner, the intensity of race day, or the prospect of performing for a live audience, something had made the pilots sharper. During Thursday's provisional heat race, even the rookie pilots displayed a disciplined élan in the air, pausing for just the right amount of time to slice cleanly through the gates and arcing around between them with competitive urgency.

By race time on Friday, the cold and wind had arrived and it was blustering, near the limits of what was safe for aerobatic performances. Red Bull course designer Martin Jehart pumped up the pylon pressure a little and declared the course viable in the wind. Sterling Price polled the pilots, who elected to race.

Mike Mangold attacked the course first. In ski racing and auto racing, there is a certain trajectory through a turn that will leave a competitor set up to enter the next turn. The best combination of these is "the line," the most effortless path a racer and his machine can trace through the course. It's not always the shortest, but it will be the fastest. Mangold found the line; his intense rehearsals at Beckwourth field had paid off. He positioned the two-point-of-four roll strategically and coasted over the Red Bull logo slow enough to make it easy to jab the stick forward and nail the center point-blank. Two gates later Mangold startled the field with a no-penalty, 2:09.68 flight. That lead would never be in serious jeopardy. Both British pilots, justifiably cautious in the unfamiliar density altitude and flying ponderous radial Sukhois, were eliminated in the opening rounds. Chambliss, already in the final by virtue of his earlier wins, ran through the course in his best airshow display manner, showing the Red Bull logo to good advantage and taking second.

On Saturday, Besenyei, Chambliss, and Mangold, all flying Edge 540s, were joined by Michael Goulian in the Castrol Cap 232 to vie for the U.S. National Championship.

First on the course, Chambliss turned in a flawless 2:03.04, the best time to date. Second up, Mangold crossed the start line 7 mph slower than Chambliss and was over a second slower at the first time mark, but aggressive flying through gate 6 enabled him to gain ground. By the next time mark, at the touch-and-go, Mangold was leading by more than seven seconds, despite a two-second penalty for touching down in the entry buffer zone. Chambliss was fast but Mangold was faster; finishing with 1:54.12, he became the first pilot to break the two-minute barrier on the Reno course. Michael Goulian had a good run, but his Castrol Cap couldn't compete with the Edge. He posted 2:12.61. That left Besenyei, who blasted through the start gate in the two-place Edge

OPPOSITE: JAMES LAWRENCE; BELOW: CAROLINE SHEEN; LOWER RIGHT: DAVID PETERS

at 255.7 mph, the fastest start in any race. Besenyei led at the first time mark by .03 second, but lost time on the remainder of the course and had to settle for third. Mangold upset Chambliss and Besenyei to become the U.S. Red Bull Champion.

In the month after Hungary, all air racing fans could talk about was how close Besenyei would get to Chambliss in the final; on Saturday all anyone wanted to know was who was Mike Mangold and could he do it again? Now, in the stands, it was a race. Regardless of who took the world title the next day, Red Bull had already won; it hooked a U.S. audience.

The sky was overcast on Sunday, but the winds had died down. The air was cooler

and thicker and the pilots were now more familiar with the course, so speeds would go up. Goulian flew a perfect routine—but couldn't break the two-minute barrier. Besenyei set a second consecutive entry speed record, 262.88 mph, but his flight fell apart as a pylon on the number-three gate collapsed after he sped past; that cost him 10 seconds, and an overshot touch-and-go added five more. It was an unexpected disaster, and the errors cost him the world championship. Without them, his time would have been an unbeatable 1:53.43.

The tension in the stands rose as it came down to the final two, the presumed champion versus the unexpected challenger. Chambliss greased the course. Despite a five-second penalty for the touch-and-go, he managed 1:59 even.

But Mangold stuck to his line. He worked through the final turns in less than 30 seconds, and fans in the crowd who weren't standing were on the edge of their seats. His time was rapidly approaching Chambliss' when Mangold dove to the final gate. When he pulled up, it was into a victory tumble that put an exclamation point on a remarkable win. His time: 1:54.84.

In 2005 the Red Bull World Cup is expanding: Ireland and the United Arab Emirates have signed on; Moscow is pending. In the United States, Reno will not host the race, but San Francisco and Miami will. At each site, there is sure to be a party like the one held on the top floor of the Golden Peacock hotel on the Saturday night of Reno's 2004 race weekend.

On one end of the penthouse, away from the flashing lights and throbbing techno of the dance floor, a big screen ran video of extreme sports: vertical skiers, base jumpers, gravity gamers with bikes and snowboards and parafoils, and the aerobatic virtuosos of the air races. The worldwide scope of the Red Bull investment and its energy message flashed powerfully in the thrills on the screen. There wasn't a checkerboard pylon in the place and no sign of a Mustang or Bearcat. There was just this screenful of Red Bull logos on young athletes executing daring stunts and flying into a future full of challenge and fun. Had airshow celebrity Bob Hoover and Reno racing legend Darryl Greenamyer elbowed their way to the bar to order a scotch, no one at the party would have had the faintest idea who they were.

Mike and Karin Goulian (left) look over the field from the balcony of the hospitality center. The sensation of the week: Mike Mangold's Dragon Edge (below, tended by pit crewman Jeff Mulhorn) stole the cup.

IT'S SHOWTIME!

2005 U.S. AIRSHOW SCHEDULE

SCHEDULE INFORMATION provided by the Department of Defense and the International Council of Air Shows (**www.airshows.org**, phone (703) 779-8510), as of February 2005. Subject to cancellation or change of city, date, name, and performers. Check local listings.

AFB Air Force Base
ANGB Air National Guard Base
ARB Air Reserve Base
EAA Experimental Aircraft Association
JRB Joint Reserve Base
MCAS Marine Corps Air Station
NAF Naval Air Facility
NAS Naval Air Station
USAF United States Air Force

ALABAMA

Birmingham Sept. 17 & 18
Wings & Wheels

ALASKA

Elmendorf AFB Aug. 13
Arctic Thunder

Eielson Aug. 17
Eielson Air Show

ARIZONA

Casa Grande Oct. 6-9
Copperstate Regional EAA Fly-In

Davis-Monthan AFB Apr. 2 & 3
Aerospace & Arizona Days (Thunderbirds)

Glendale Oct. 21-23
Thunderbird Balloon and Air Classic

Kingman Oct. 1 & 2
Kingman Air and Auto Show

Luke AFB Mar. 19 & 20
Luke Days Air Show (Thunderbirds)

MCAS Yuma Feb. 26
MCAS Yuma Air Show

Valle Airport June 25 & 26
High Country Warbirds Fly-In

Valle Airport Oct. 8 & 9
Antique & Classic Aircraft Fly-In

ARKANSAS

Fayetteville June 17-19
Arkansas Air Museum Airfest

Thermal Nov. 4
Desert Resorts Air Show

Travis AFB Oct. 15 & 16
Travis Air Expo (Thunderbirds)

Watsonville May 27-29
Watsonville Fly-In & Air Show

COLORADO

Colorado Springs July 9 & 10
In Their Honor Air Show

Grand Junction Aug. 13 & 14
Colorado Air Show (Blue Angels)

Peterson AFB Field June 4
Peterson AFB Air Show (Thunderbirds)

FLORIDA

Daytona Beach Oct. 28-30
Daytona Beach Air Show

Ft. Lauderdale Apr. 30 & May 1
Air & Sea Show (Thunderbirds)

Ft. Myers May 14 & 15
Ft. Myers Beach Air Show

Ft. Pierce-St Lucie County May 21 & 22
Wings 'n Wheels Air, Military & Vehicle Show

Gainesville Sept. 24 & 25
Wings Over the Heart of Florida (Blue Angels)

Immokalee Apr. 23 & 24
Ian Groom Memorial Speed Spectacular

INDIANA

Elkhart Aug. 6 & 7
Elkhart Air Show

Evansville June 24-26
Evansville Freedom Festival (Blue Angels)

Gary July 16 & 17
Gary Air Show

Indianapolis Aug. 27 & 28
Indianapolis Air Show (Blue Angels)

Terre Haute July 23 & 24
Terre Haute Air Fair (Thunderbirds)

IOWA

Burlington Sept. 17
Burlington Regional Air Show

Clarinda Sept. 10 & 11
Fly Iowa Air Show

Davenport June 25 & 26
Quad City Air Show (Thunderbirds)

Dubuque July 3
Dubuque Air Show

KANSAS

McConnell AFB Sept. 24 & 25
AVN Festival

KENTUCKY

Louisville Apr. 23
Thunder Over Louisville

Joplin June 26 & 27
Joplin Airfest

Poplar Bluff May 7
Poplar Bluff Air Show

Springfield July 4
I Love America Air Show

St. Louis July 2-4
Fair St. Louis

MONTANA

Kalispell July 30 & 31
Mountain Madness (Blue Angels)

Malmstrom AFB June 5
Malmstrom AFB Air Show (Thunderbirds)

NEBRASKA

Offutt AFB Aug. 27 & 28
Offutt AFB Air Show

NEVADA

Nellis AFB Nov. 12 & 13
Aviation Nation 2005 (Thunderbirds)

Reno Sept. 14-18
National Championship Air Races (Snowbirds, Thunderbirds)

NEW JERSEY

Atlantic City Aug. 31
Thunder Over the Boardwalk (Thunderbirds)

Camden Aug. 6
Battleship New Jersey Aviation

NORTH DAKOTA

Fargo July 9 & 10
Fargo AirSho (Blue Angels)

Sturgis Aug. 8 & 9
Sturgis Air Show

OHIO

Akron June 18 & 19
Aero Expo Defenders of Freedom Air Show

Cincinnati June 11 & 12
Blue Ash Airport Days

Cleveland Sept. 3-5
Cleveland National Air Show (Thunderbirds)

Dayton July 16 & 17
Vectren Dayton Air Show (Thunderbirds)

OKLAHOMA

Oklahoma City June 17-19
Aerospace America International Air Show

Tinker AFB July 2
Star Spangled Salute (Thunderbirds)

OREGON

Hillsboro Sept. 9-11
Oregon International Air Show (Thunderbirds)

Dyess AFB May 21
Dyess AFB Open House

El Paso Oct. 8 & 9
Amigo Airsho

Ft. Worth Sept. 24 & 25
Ft. Worth International Air Show (Blue Angels, Snowbirds, Thunderbirds)

Ft. Worth Oct. 15 & 16
TCU Ft. Worth Air Show

Galveston Apr. 23 & 24
LSFM Spirit of Flight

Galveston Nov. 13
Lone Star Flight Museum Fly-Day

Hondo May 13-15
Big Country EAA SW Regional Fly-In

Houston Oct. 8 & 9
Wings Over Houston (Snowbirds)

Laredo Feb. 13
Stars & Stripes Air Show Spectacular

Laughlin May 14
Air Amistad (Thunderbirds)

Midland Oct. 1 & 2
FINA-CAF Airsho

NAS Corpus Christi Apr. 9 & 10
South Texas Shootout (Blue Angels)

Randolph Nov. 5 & 6
Randolph AFB Air Show (Thunderbirds)

Little Rock AFB Oct. 8 & 9
Little Rock AFB Air Show (Thunderbirds)

CALIFORNIA

Chino May 21 & 22
Planes of Fame Air Show

Edwards AFB Oct. 22 & 23
Edwards AFB Open House

El Cajon Apr. 29-May 1
Wings Over Gillespie

Hemet June 11
Hemet-Ryan Air Show

Marysville June 3-5
Golden West EAA Regional Fly-In

NAF El Centro Mar. 12
NAF El Centro Air Show (Blue Angels)

NAS Point Mugu Oct. 22 & 23
Point Mugu Air Show (Blue Angels)

Ramona June 25 & 26
Ramona Air Fair

Riverside Apr. 2
Riverside Air Show

Sacramento May 7
Capital Air Show

Salinas Sept. 30-Oct. 2
California International Air Show (Thunderbirds)

San Angelo Oct. 8
Rio Concho Air Show

San Carlos June 18
Vertical Challenge Helicopter Show

San Diego Oct. 14-16
MCAS Miramar Air Show (Blue Angels)

San Diego Sept. 2 & 3
San Diego Aerospace Museum Air Show

San Francisco Oct. 8 & 9
San Francisco Fleet Week Air Show (Blue Angels)

Santa Maria Aug. 26-28
Thunder Over the Valley

Santa Rosa Aug. 20 & 21
Wings Over Wine Country Air Show

Shafter May 14
Warbirds in Action

South Lake Tahoe Sept. 4
Tahoe AirFest

Jacksonville Beach Nov. 5 & 6
Jacksonville Beach Air Show (Blue Angels)

Lakeland Apr. 12-18
Sun 'n Fun EAA Fly-In

NAS Pensacola Nov. 11-13
Blue Angels Homecoming (Blue Angels)

St. Petersburg Oct. 8 & 9
Suncoast AirFest

Stuart Nov. 11 & 12
Stuart Air Show

Titusville Mar. 11-13
TICO Warbird Air Show

MacDill AFB Apr. 9 & 10
MacDill Airfest (Thunderbirds)

Pensacola Beach July 2 & 3
Pensacola Beach Air Show (Blue Angels)

Punta Gorda Mar. 19 & 20
Florida International Air Show (Blue Angels)

Tyndall AFB May 14 & 15
Gulf Coast Salute (Snowbirds)

GEORGIA

Augusta Oct. 15 & 16
Boshears Memorial Fly-In

Columbus Mar. 19 & 20
Thunder in the Valley Air Show

Moody AFB Apr. 9
Team Moody Air Fest

Vidalia Apr. 23 & 24
Vidalia Onion Festival Air Show (Blue Angels)

IDAHO

Mountain Home Sept. 16-18
Gunfighter Skies (Thunderbirds)

Nampa June 18
Nampa Air Show

ILLINOIS

Chicago Aug. 20 & 21
City of Chicago Air & Water Show (Thunderbirds)

LaSalle/Peru June 18
Peru Air Show

Peoria Aug. 5-7
Prairie Air Show

Scott AFB Aug. 6 & 7
Scott AFB Open House

Springfield Sept. 16
Springfield Air Rendezvous

LOUISIANA

Barksdale AFB May 14 & 15
Barksdale AFB Air Show (Blue Angels)

New Orleans Oct. 22 & 23
N'Awlins Air Show (Thunderbirds)

MAINE

NAS Brunswick Sept. 10 & 11
Great State of Maine Air Show (Blue Angels)

MARYLAND

Andrews AFB May 20-22
DoD Joint Services Open House (Thunderbirds)

NAS Patuxent River Sept. 3 & 4
Southern Maryland Aviation Days (Blue Angels)

MASSACHUSETTS

Otis ANGB Aug. 6 & 7
Cape Cod Air Show

Westfield Aug. 27 & 28
Westfield International Air Show (Thunderbirds)

MICHIGAN

Battle Creek July 3 & 4
Battle Creek Balloon Championships (Snowbirds, Thunderbirds)

Muskegon July 23 & 24
Muskegon Air Fair (Blue Angels)

Selfridge ANGB July 23 & 24
Salute to the Veterans of Vietnam

Ypsilanti Aug. 6 & 7
Thunder Over Michigan

MINNESOTA

Duluth Aug. 27 & 28
Duluth Air & Aviation Expo

Redwing May 27
Wings of Freedom

MISSISSIPPI

Keesler AFB Nov. 5
Keesler AFB Air Show

Natchez May 21 & 22
Natchez Air Fair

MISSOURI

Chesterfield Sept. 3-5
St. Louis County Fair & Air Show

Columbia May 28 & 29
Salute to Veterans Celebration

Awareness Day

McGuire AFB June 4 & 5
McGuire AFB Air Show (Blue Angels)

Millville May 6-8
Wheels & Wings Air Show

Somers Point June 4
Atlantic County Day/Bay Air Show & Festival

NEW MEXICO

Cannon AFB Sept. 10
Air Power Expo

Holloman AFB Apr. 17
Holloman Open House (Thunderbirds)

Tucumcari Sept. 28
Tucumcari Rotary Club Air Show (Snowbirds)

NEW YORK

Adirondack Aug. 20 & 21
Adirondack Air Show

Elmira July 23 & 24
Wings of Eagles

Geneseo July 8-10
History of Flight & Biplane Rally

Oswego July 30 & 31
Oswego Harborfest

Rochester June 11 & 12
Rochester International Air Show (Thunderbirds)

Schenectady July 9 & 10
ESAM Northeast Air Show

Wantagh May 28 & 29
New York Air Show at Jones Beach State Park

NORTH CAROLINA

Franklin Oct. 22
Macon County Air Show

Lumberton May 12-15
Lumberton Air Show

MCAS Cherry Point May 7 & 8
MCAS Cherry Point Air Show (Blue Angels)

Pope AFB May 28 & 29
43rd Airlift Wing Open House (Snowbirds)

Seymour Johnson AFB Nov. 5 & 6
Seymour Johnson AFB Air Show

Winston-Salem Sept. 10 & 11
Winston-Salem Air Show

Wilmington Apr. 15-17
Coastal Carolina Air Show (Blue Angels)

PENNSYLVANIA

Lock Haven July 23 & 24
Lock Haven Air Show

NAS JRB Willow Grove May 28 & 29
NAS JRB Willow Grove Air Show (Blue Angels)

Pittsburgh July 9 &10
Wings Over Pittsburgh (Thunderbirds)

Reading June 3-5
World War II Weekend

West Chester June 19
Dad's Day at American Helicopter Museum

West Chester Oct. 15 & 16
Rotorfest All Helicopter Air Show

RHODE ISLAND

North Kingstown June 18 & 19
Rhode Island Air National Guard Open House (Blue Angels)

SOUTH CAROLINA

Camden Oct. 28-30
Celebrate Freedom Air & Ground Show

Charleston AFB Apr. 30
Charleston AFB Air Expo (Blue Angels)

Florence Apr. 30 & May 1
May Fly Air Show

Myrtle Beach June 4 & 5
Sun Fun Festival

Shaw AFB Apr. 23
ShawFest (Thunderbirds)

TENNESSEE

Chattanooga Oct. 28-30
Air Show Chattanooga (Blue Angels)

Millington Oct. 1 & 2
MidSouth Air Show (Blue Angels, Snowbirds)

Smyrna May 7 & 8
Great Tennessee Air Show (Thunderbirds)

TEXAS

Abilene Sept. 24
Big Country AirFest

Brownsville Mar. 12 & 13
Air Fiesta

Corpus Christi Oct. 1 & 2
Bayfest

Denton May 21
Denton Air Fair

San Antonio Apr. 16
Fiesta Air Show

UTAH

Wendover Sept. 22-24
Wendover Airfield Air Show

VIRGINIA

Langley AFB May 13-15
Air Power Over Hampton Roads (Thunderbirds)

Richmond Oct. 15 & 16
Chesterfield County Air Show

Virginia Beach Sept. 17 & 18
NAS Oceana Air Show (Blue Angels)

WASHINGTON

Arlington July 6-10
Arlington EAA Fly-In

Fairchild AFB July 23 & 24
Inland NW Skyfest

McChord AFB July 30 & 31
McChord Air Expo (Thunderbirds)

Pasco July 29-31
Tri-City Water Follies

Seattle Aug. 6 & 7
Seafair (Blue Angels)

Tacoma July 4
Tacoma Freedom Festival Air Show

WISCONSIN

Janesville June 11 & 12
Southern Wisconsin AirFEST (Blue Angels)

La Crosse June 18 & 19
Deke Slayton Airfest (Thunderbirds)

Manitowoc June 4 & 5
Manitowoc Air Show

Milwaukee July 16 & 17
TCF Bank Air & Water Show (Blue Angels)

Oshkosh July 25-31
EAA Airventure

WYOMING

Cheyenne July 27
Cheyenne ANG Air Show (Thunderbirds)

RICHARD VANDER MEULEN

AIR & SPACE/SMITHSONIAN 2005 U.S. AIRSHOW SCHEDULE

SO YOU WANT TO BE AN AIRSH

IT'S NOT AS GLAMOROUS AS

DAVID CARLSON

COURTESY SKIP STEWART

Journeyman airshow pilot Skip Stewart would love to achieve the success of the industry's biggest solo act, Sean D. Tucker, always a favorite at the annual Oshkosh, Wisconsin airshow (left).

HOW IT LOOKS. PILOT

BY PHIL SCOTT

JANESVILLE, WISCONSIN. POPULATION 60,483. It's a medium-size, middle-class city in middle America, 105 miles northwest of Chicago. This bright, sunny June weekend it's also the site of Southern Wisconsin's AirFEST 2004. If this were baseball, Janesville's AirFEST would be AAA league, a farm team for the majors. Since AirFEST can't pay the hefty fees charged by the industry's big-name pilots, the show gives lesser-known performers a chance to shine.

Skip Stewart is getting ready for his act by performing a ritual called the Aresti Dance: In a world all his own, he steps back and forth, "flying" his show routine with spread arms, sometimes using his left hand to slice or pour on the power or his right to jockey a phantom control stick. He wears a black flightsuit with red stripes, and on his feet, black Converse All-Stars. A little on the short side, Stewart, 37, has a broad back, brown eyes, and curly brown hair. If I weren't so macho, I'd say he's good-looking. He's charismatic too: Instantly, you just *want* him to like you. He has a touch of a Southern accent, that down-home first name (Skip's real name is William Lewis Stewart), and a proclivity for fast driving and getting pulled over by the law (six times in the last five years).

Sitting in the sun and paying no attention to the dance routine is Stewart's fiancée, Christina Cantrell. She is blonde, looks like a model, and wears a red flightsuit with black stripes (the opposite of Skip's). Filling Stewart's Pitts biplane, *Prometheus*, with smoke oil is Stewart's friend C.J. Kirby, a cop in real life who just got his pilot's license a few months ago. Kirby flew Cantrell to the show in a silver two-seat Grumman Yankee that a friend lent Stewart for the summer.

This is Stewart's second show in Janesville. He flew the 2002 show, and now he's back in 2004. For 2003, Janesville's AirFEST organizers hired Jim Leroy instead. That happens. Stewart's not a big name—not yet, anyway.

In the world of airshow pilots, the biggest name is Sean D. Tucker,

"Dangerous, that's the name of the game," says John Cudahy. "It's not really dangerous, but the pilot's showmanship is to make it look as thrilling as possible."

who flew his first airshow in 1976. His main sponsor is software giant Oracle, which sets up a hospitality tent at each airshow so that corporate guests can socialize in private with a star of Tucker's wattage.

At the AirFEST performers' "comfort tent," the comforts seem kind of thin. There are faux-wooden banquet tables and metal chairs lined up in rows. The food isn't all that exciting: soda, coffee, chicken, slabs of beef, raw vegetables, trail mix, and deep-fried cheese curd. Stewart, Cantrell, and Kirby fill small paper plates but end up picking at the food.

Then the performances begin. Fledgling airshow pilot Jacquie Warda stops by the comfort tent to beg off her scheduled flying routine with Stewart. "I hadn't done a dual before, and we kind of came up with it at the last minute, and I was a little uncomfortable with it," she says. So the now-solo Stewart takes to the sky at 1:30 p.m. His routine, from the first vertical nosedive, through several gyrating tumbles, and on to the low, low knife-edge ribbon cut, lasts but 15 minutes. It's a heart-in-your-throat quarter-hour during which you're praying that this maniac doesn't die.

Of course one of the primeval desires of the crowds at an aerobatic performance is to witness a spectacular crash—to see an airplane just plow right into the ground. "Dangerous, that's the name of the game," says John Cudahy, president of the International Council of Air Shows. "It's not really dangerous, but the pilot's showmanship is to make it look as thrilling as possible without it being dangerous. The most dangerous maneuvers are the ones people don't think are dangerous and vice-versa. It's a matter of perception."

After his performance, Stewart lands and taxis before the crowd line, smiling and waving. He's eating up the applause. He parks, shuts down the engine, and leaps out to meet his fans.

When he's not looping his Pitts biplane at airshows, Stewart flies jet transports for Federal Express.

LEFT: JOHN PERKINSON; BELOW: COURTESY SKIP STEWART

KARL KOEPPEN (2)

He loves giving his autograph and handing out pictures of himself with his airplane. And he loves talking, especially about his act, his airplane, and himself. Ego? "Yes," he says without thinking about it. Then he tries to explain: "There are no selfless acts, except maybe throwing yourself on a grenade. If you didn't like the attention, just fly solo in your practice box."

Even aside from the gut-wrenching aerobatics, being an airshow performer isn't for the faint of heart. It's a long, hard slog to the top.

Six seasons ago, after a few years in aerobatic competitions, Stewart started flying his show routine. He flew one airshow that year. His second year he flew nine shows, charging $500 a show if he could get it. Each performer sets his own fee (there is no airshow performers union). Sometimes Stewart would just show up at an airshow, and if the weather turned crummy, maybe a performer or two might drop out or not make it and organizers would let him go on. In 2002, Stewart flew seven shows, asking $1,500 a pop. The next year, he flew 10 shows for $2,000 each, then last year he received $2,950 per show for 10 shows. For this season, he's hiking his price to $4,900. Not that he's carved that fee in stone; it's just what he thinks someone at his level should make.

Even if Stewart succeeds in flying eight or so shows this season at $4,900 apiece, his earnings won't cover his expenses. He easily spends his whole take on maintaining and rebuilding *Prometheus*: It costs him $40,000 a year to fly a single airshow season and $3,600 to insure the Pitts.

Stewart can save some money with his volunteer crew—his fiancée and Kirby. Kirby fuels and polishes *Prometheus*, and makes sure the airplane has enough smoke oil for the act. As for maintaining the Pitts, Stewart does most of the work himself.

Besides the fees airshow pilots charge to perform, they earn money through sponsorship—how performers like Tucker make the real bucks. Instead of cash, most of Stewart's sponsors contribute replacement parts for his airplane or give him deep discounts in exchange for getting their logos painted on *Prometheus*. Scheunemann Aviation Products donated the wings, Whirlwind gave Stewart a discount on the propeller, and Avworks is building a new, nearly 400-horsepower engine. Another sponsor, Airshow Models, sells 1/32-scale plastic models of *Prometheus* for $85 at *Airshowmodels.com*. (The author has not been compensated for this announcement.)

"He needs more sponsors," says Cantrell.

"Raven [Aircraft] has gotten a great deal from me just because I like their logo," says Stewart. But this may be the end of such bargains for sponsors. "I am breaking into a different level now, and I feel I can bring better deals," he says. Don't cry for Skip, Argentina: He flies jet transports for Federal Express. If you want to make it in the airshow business, for the first few years, you've got to have a great day job. Sean Tucker, for instance, dusted crops.

Tucker has been a big influence on Stewart, as was the late Leo Loudenslager. When he was just a kid, Stewart—who'd been introduced to flying by his grandfather, and had spent his teen years building and flying radio-controlled models—witnessed Loudenslager perform. "It was my first airshow, and the first time I had seen anyone fly a real airplane the way I flew a model airplane," Stewart recalls. "When I saw Leo fly, I knew I wanted to put myself in a position to someday be able to at least try to fly like that and hopefully give others the feeling he gave me."

"I love it," says Tucker. "I don't know when I'm going to quit." Oracle provides a hospitality tent for guests and pays the salaries of Tucker's staff (below).

TYSON RININGER

Jacquie Warda quit her job as a legal secretary in May 2001 to launch a full-time career as an airshow pilot.

"It's going to be several years before I can make a profit," says Warda. "In essence, you can't be in this business if you can't afford the airplane."

At age 23, Stewart saw Tucker flying at the 1991 Oshkosh, Wisconsin fly-in. "He took the out-of-control tumbling maneuvers others would do and turned them into perfectly choreographed maneuvers and did them low," Stewart says. "He redefined what hardcore airshow aerobatics was about."

Tucker's climb to the top wasn't without a few detours. From his home in the hills between Salinas and Monterey, California, Tucker, 52, tells me by telephone how he began in the business. "When I started I was a total failure," he says. "I had a lot of passion and not a lot of skill." He pauses for a beat. "I didn't have any *death* perception," he explains, laughing. (Like Stewart, Tucker has the charm market corralled.) In 1979, Tucker was practicing for his first big show when he got into an unrecoverable inverted flat spin. He bailed out, but his Pitts pancaked into the ground. Tucker refers to the event as "the crash of '79" and says, "I knew I had to get my act together because I was married, broke, and had no options." Soon after, he started dusting crops by helicopter; it wasn't the kind of flying he dreamed of, but it helped pay the bills.

Tucker didn't return to airshow flying until 1988, and four years later he landed his first monetary sponsor, Randolph Sunglasses. Financially, Tucker is the envy of many in the industry. The sponsorships he has from companies who supply airplane parts and aviation products save him $80,000 a year, and on top of that, he has the (undisclosed) monetary backing of Oracle.

Tucker's crew consists of two full-time mechanics, one full-time public relations manager, a hospitality manager to handle Oracle clients, and a business partner who doubles as a quality-assurance guy, coming to every third show to check on the mechanics' work and to grade Tucker's flying. "I have a fairly big infrastructure," says Tucker. "They're very talented. And when you have the best talent, you have to pay them well—they make more than 99 percent of the airshow pilots in this industry, unfortunately."

Fortunately, Oracle covers everyone's salaries (including Tucker's), plus all travel and operating expenses. In return, Tucker flies 20 high-visibility airshows a year, gives motivational speeches, signs autographs for select groups—whatever the company asks him to do. "They own me lock, stock, and barrel," he says, laughing. "It is my

day job." The financial comfort Tucker now enjoys has allowed him to pursue another interest: mentoring novice pilots at an aerobatics flight school he runs in King City, California. "My flight school is my passion, but it doesn't make any money," says Tucker, who is just shy of breaking even on the costly venture. To help underwrite his school, Tucker also flies at non-Oracle-sponsored airshows, for which he charges a fee of $8,500.

Making it pay. There's the rub. Jacquie B Warda (the "B" is for "Baby," as in "Jacquie Baby," a nickname bestowed by Tucker) has a résumé much like Stewart's. She flew in aerobatic competitions before getting bitten by the showbiz bug. She's a brunette, not hard to look at, and rides a Harley-Davidson when at home in Danville, California. She also flies a Pitts. For the 2004 season, her second, she flew eight shows; in 2003, she flew four. She did not get paid for the shows she flew her first season because she didn't have a commercial pilot's license, and only commercial-rated pilots can charge for their services. (A private pilot who receives any form of compensation, be it a tank of fuel or even a sandwich, is violating federal aviation regulations.) Last year, she earned $2,000 for most of the shows, and the organizers of one show even paid a whopping $2,500.

Warda, 51, is doing better at this point in her career than Tucker and Stewart did early on, but she's not exactly swimming in sponsorship money. She is backed by AeroShell, Goodyear Tires, Hooker Harness, and a sport-parachute manufacturer, Para-Phernalia, all of whom she won over by the force of her personality. Says Warda: "You've heard that fairly big, old adage: 'It's who you know, not what you know.' " At Reno, Nevada, where she races her Pitts, she got to talking with Gene McNeely, the second quarter of the AeroShell team, and he offered to introduce her to potential sponsors. She met a few big names and they liked her, but they offered only products—no money. "It's going to be several years before I can make a profit," she says. "In essence you can't be in this business if you can't afford the airplane." Right now, Warda's husband, who is the crew chief for her Pitts, is supporting them both by working as a computer programmer. Her day job is to fly the airplane and improve her skill and showmanship in the air.

For beginners like Warda, building popularity on the airshow circuit starts with solid performances in the air and continues with people skills on the ground.

After seeing Stewart perform twice at Janesville in June, I meet up with him again in October, at Skyfest Tennessee in Jackson, his next-to-last show of the season. He picks me up at the Memphis airport (where FedEx is based), and we drive to the McMansion he and Christina Cantrell share, in a suburban development of twisty streets filled with identical McMansions. The only thing that differentiates his from the others is the garage full of a Wittman Tailwind, which he and C.J. Kirby built in their spare time. Inside, in a kitchen as vast as a basketball court and cleaner than an operating room, sits a pool table and three shelves filled with Stewart's aerobatic medals, certificates, and trophies.

The next morning, Saturday, we drive an hour to Jackson, another midsize, middle-American city. Since rain threatens, many of those in attendance are gathered under the VIP tent. A smaller number of visitors wander around, taking in the petting zoo, the booth selling kettle corn, the static displays of aircraft and antique automobiles. The rain clouds lighten but the ceiling remains low; to kill time, the opening act, radio-controlled aircraft models, goes long. A few people grow weary of waiting and leave.

Airshow royalty—community leaders, sponsors, performers, anyone wearing a neck chain with the proper credentials—stay beneath the VIP tent, where two guards check your pass before allowing you to enter. The food is great, and all the tables have white tablecloths. And you have a front-row seat for the show.

Stewart is up twice. For his first performance, he flies a sort of aerobatic Dueling Banjoes with a friend, Greg Bird, who's piloting his Extra 300 monoplane. Bird credits Stewart, whom he met during aerobatic competitions, with getting him his first airshow slot, in 2001. To receive Federal Aviation Administration certification to perform aerobatics in front of an airshow audience, Bird first had to be evaluated—in the air and on the ground—by an accredited aerobatic competency evaluator. Bird's ACE gave him a passing grade and signed him off for a 500-foot floor, which means he can't perform any maneuvers below that altitude. (Usually the first floor is 800 feet, but

MIKE SATREN/HIGH WING PHOTO IMAGES

OPPOSITE: TYSON RININGER

Jim Leroy covers his modified Pitts, Bulldog, *with the logos of companies that give him aviation equipment. Such donations can save an airshow pilot thousands of dollars a year, but every pilot dreams of getting a corporate paycheck too. Opposite: Stewart is still waiting for a big-bucks sponsor to advertise its name across his airplane's wings.*

"When I saw Leo fly," says Stewart, "I knew I wanted to put myself in a position to be able to at least try to fly like that and hopefully give others the feeling he gave me."

Bird really impressed the ACE). After 12 performances at six shows, Bird went before the ACE for a second evaluation, and got signed off to perform down to 250 feet. This is his final performance at that altitude. Now he's qualified to apply for a ground waiver, which would permit him to fly as low to the ground as he wants.

"Airshows are a lot of fun," says Bird. "In competition flying, everything's mechanical and precise. Show performance is physically demanding, and it allows me to be creative; it allows me to express my inner self." Bird says he'll probably fly the occasional show for fun. He'll also keep flying aerobatic competitions, but notes that Stewart seems to have given them up. "He has a huge airshow focus," says Bird.

All ACEs are certified by the International Council of Air Shows, which relieved the FAA of responsibility for the program in 1991, after an alarming period in the late 1980s and early 1990s when the airshow community was experiencing nearly 10 fatal accidents per year. "The difference between a mediocre and outstanding aerobatic pilot isn't perceptible to anyone who doesn't live and breathe this stuff," says ICAS's John Cudahy. "We had maybe seven fatal accidents that first year, and we've never had more than five deaths since." The four fatal accidents that occurred in 2003 were the most in seven years.

The typical ACE is an airshow veteran, someone like Alan Henley, the third quarter of the AeroShell Aerobatic Team (his brother, Mark, is the fourth). Henley is 46 years old, and he figures he'll be flying shows for maybe 20 years more. "I was one of the first [ACEs] when the system was started about 10 years ago," he says. What qualifies a pilot to become an ACE? Among other things, you must have flown at least 50 airshow performances. Henley has. He figures he does eight evaluations a year. Once a year, every performer is required to undergo an ACE evaluation. Even an ACE. Even Sean Tucker.

Just before Stewart begins his final performance of the day, C.J. Kirby organizes six of us to hold the poles for Stewart's ribbon cutting. We walk through a field of shorn hay out to the runway and take our places on either side of it. Stewart's fiancée sits cross-legged on the ground, shielding her eyes from the sun, the better to watch Stewart. "Doesn't seeing him do this make you nervous?" I ask her. She looks at me as if I've questioned the need to wear shoes in winter. "No," she replies slowly. "He's doing what he wants to do."

Standing there, gripping the pole with an older man and an 11-year-old boy, I watch Stewart's act and think that it doesn't seem as dangerous as the first time I saw it three months earlier at Janesville. Maybe it's my proximity to *Prometheus*, or maybe my perception has changed because of the

number of times I've seen Stewart perform. This is the first time I've held the pole, though, and when *Prometheus*' propeller cuts through the ribbon, the pole pulls hard. A few seconds later, we're all gagged by smoke oil.

Second- and third-tier airshow performers sometimes suffer indignities and slights that first-tier performers aren't as likely to be subjected to. Before his act just now, the show's air traffic controller held Stewart on the ground while the transport for the U.S. Army Black Daggers Parachute Team rolled out to the runway. To keep *Prometheus*' engine from overheating, Stewart shut it down. After he performs and lands, the tower orders him to stop again, this time on the taxiway, to allow the Black Daggers to jump out and slowly float to the ground. Stewart shuts off the engine again, but when he tries to start it, the tiny battery gives out. The tower dispatches a truck to jump-start the engine while the afternoon heat slow-cooks Stewart inside the cockpit. Meanwhile, the fans who have dashed to the performers' parking area, expecting to meet Stewart, walk away looking dejected. A few stand by until *Prometheus* wheels up and whips around and Stewart bounces out of the cockpit all smiles, ready to sign autographs and answer questions as if he's never heard anyone ask them before. While digging around for more photos in a cloth bag, he mutters to no one in particular, "They'd never do *that* to Sean Tucker."

Before leaving the airshow, I ask Stewart what he's learned since Janesville. If he's improved his act in some way, my eye is not discerning enough to detect it.

"Honestly, I don't think Jackson was that much, if any, better than Janesville from a spectator point of view," he says. "I did learn from Janesville to Jackson how important it is to be around the plane when the show is over. This seems to be when the real fans come around and want to talk and interact. Sponsors are becoming easier to get. I got an engine sponsor, which is worth ten to fifteen thousand to me. I have a company after me to sign a contract allowing them exclusive rights to seek sponsorships in the $300,000-plus range."

Then Stewart shakes my hand. When I'm back in Memphis or if FedEx business brings him through my town, New York City, we'll get together, he promises. You have to believe someone with that much charm.

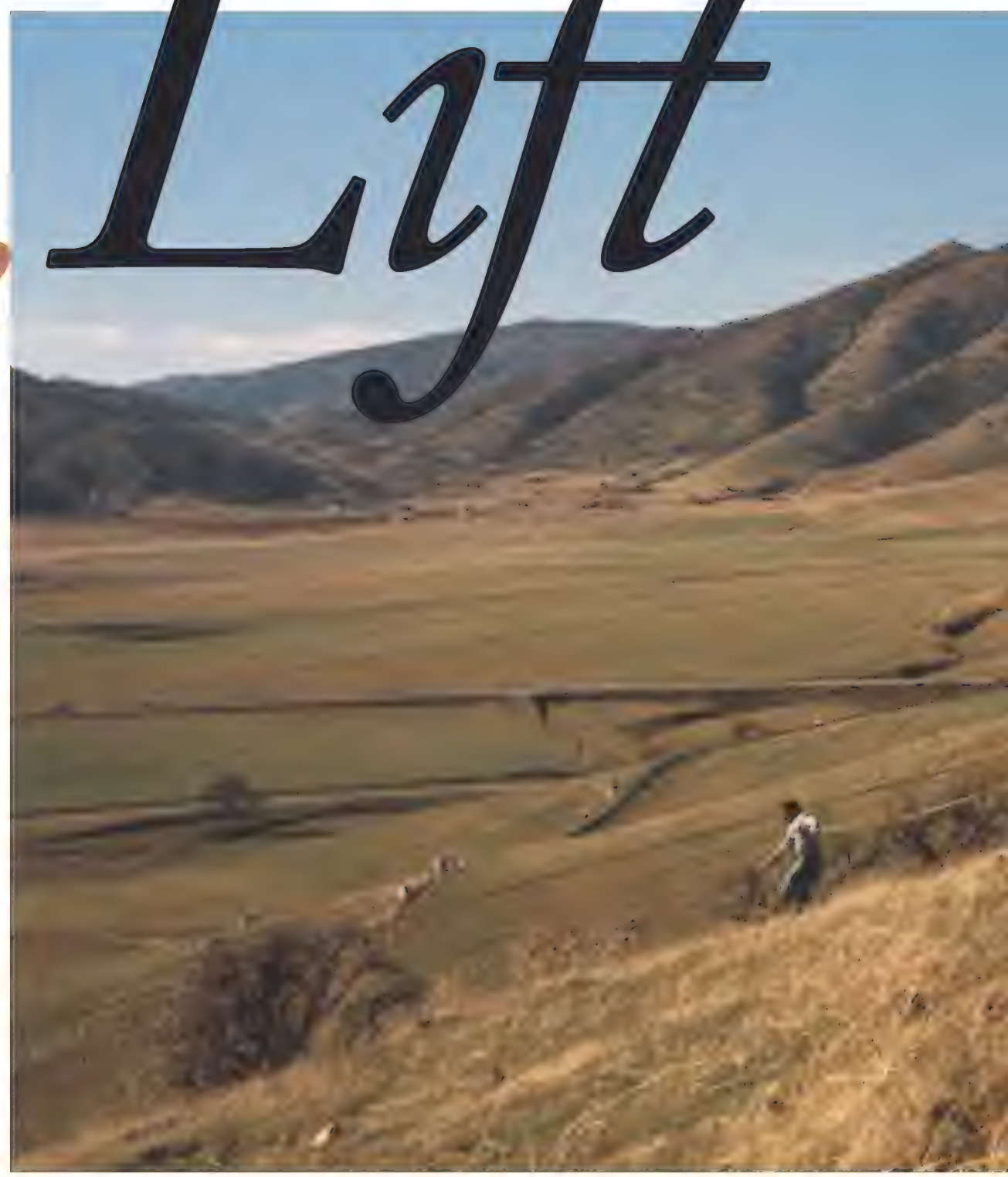
Kirby walks me to my rental car. "He has a natural talent for it," he says along the way. "He's going to be Number One here before too long."

A few months later, I e-mail Stewart to catch up. He e-mails back and tells me that a couple of guys want to do a 13-episode reality TV show around him. He also mentions that he met up with Sean Tucker at last December's ICAS convention, and that the two had a friendly conversation. "[Tucker] said he looked forward to actually seeing me fly, and I told him he was my inspiration and I had thought of him as my hero," says Stewart. He also adds that he might be one of the many performers at the Experimental Aircraft Association's annual airshow in Oshkosh this summer. The EAA doesn't pay its performers, but the Oshkosh airshow would be phenomenal exposure and a sure sign that Stewart has made it. "Keep your fingers crossed!" he says. "Dream-come-true territory here." They're crossed, Skip.

OPPOSITE: TYSON RININGER

JOHN PERKINSON

a little Lift



Pilots of new, ultra-sensitive sailplanes have learned to use every micro-gust.

by Paul Ciotti

It is shortly after eight in the morning at El Mirage dry lake, a cracked and dusty expanse in the high desert 55 miles northeast of Los Angeles. Despite the big plumes of yellow smoke from wildfires on the far side of the San Gabriel Mountains to the south, up here on the lakebed it is clear and quiet as sailplane designer Danny Howell does a preflight checkout of his ultra-lightweight sailplane, the LightHawk.

"There's not a straight line on it anywhere," boasts the Northrop Grumman engineer, sighting the prototype's gently swelling 15-meter (49 feet) elliptical wings. From above, the wings look more like those of a large seabird than anything you'd see on an airplane. According to Howell, that's the whole idea: to build an unpowered aircraft that not only imitates the efficiency of soaring birds but also can fly as slowly as they do...in the LightHawk's case, a mesmerizingly slow 23 mph.

This morning's flight will be only the seventh time the LightHawk has been in the air, so Howell and his half-dozen crew members are extremely cautious. After a prolonged inspection of the aircraft, Howell gives the go-ahead to test pilot Galen Fisher. Fisher calls the driver of the tow vehicle, 1,800 feet down the lakebed, to tell him to get moving, and in 30 seconds Fisher has risen to 600 feet, where he releases the tow rope, eases into a right turn over the scrub and Joshua trees, and begins to search for rising air.

There's not much out there this early in the day, and within a few minutes Fisher has fallen to 200 feet and is starting to think about landing when he notices a raven slowly circling nearby. Fisher maneuvers over to join him, and soon they both are slowly rising at a nearly imperceptible hundred feet per minute. The higher they go, the better the lift seems to be, and within half an hour Fisher is cruising comfortably at 8,500 feet, where the sailplane sinks at such a slow rate—Howell estimates just 1.3 feet per second—that in the words of one test pilot, the craft appears to "fly around horizontally."

At 200 pounds, the LightHawk, which has gone on to make 20 flights, is the latest and most technologically sophisticated entry in an emerging class of low-inertia sailplanes—super-light, super-efficient gliders with such low airspeeds and sink rates that they can stay aloft far longer than every other kind of sailplane. This class includes

COURTESY SAILPLANE HOMEBUILDERS ASSOCIATION

CHAD SLATTERY

Above: Les King bungee-launches Dan Armstrong and a Carbon Dragon near Tehachapi, California. Pilots have used the Carbon Dragon to flesh out a whole new method of bird-like gliding called dynamic soaring. Right: Danny Howell's curvy LightHawk represents the latest technological leap for micro-lift aircraft. It is the world's lightest 15-meter-wingspan sailplane.

CHARLES PECK

TIM ETTRIDGE

Gary Osoba (left) has twice set two soaring records with a single flight of the prototype Carbon Dragon (above).

the 101-pound, Swiss-built, open-cockpit Archaeopteryx, the German-made ULF-1 glider, increasingly efficient rigid-wing hang gliders, and the venerable 145-pound Carbon Dragon, a balsa wood and carbon-fiber sailplane that in recent years has acquired almost mythic status for its unique ability to stay aloft on "micro-lift"—the weak energy that can be extracted from the fleeting gusts, burbles, and meandering air streams found below 1,000 feet.

Designer Jim Maupin first conceived of the Carbon Dragon in the late 1970s, when there was no such thing as a low-inertia sailplane. He intended the Carbon Dragon to be a superlight craft that would have the maneuverability of a slow-flying hang glider but the high lift-to-drag ratio of a rigid-wing sailplane.

"His goal was to set a world [distance] record from a foot-launched aircraft," says Dan Armstrong, a Tehachapi, California-based aeronautical engineer who at the time was one of the young soaring enthusiasts helping Maupin build the sailplane. In time, the sailplane would fulfill the dream; Wichita-based entrepreneur Gary Osoba now owns the prototype, which he has flown to four distance world records and one speed-over-distance record. Its unique characteristics also have opened up a whole new method of soaring. With a 44-foot wingspan, a 1.7-foot-per-second minimum sink rate, a 20 mph stall speed (in contrast to a typical 15-meter ship's 40 mph), and a roll rate of about 27 degrees per second, the Carbon Dragon was the first sailplane to take advantage of micro-lift, using a technique known as dynamic soaring.

Unlike conventional soaring, in which pilots attempt to lift their sailplanes to higher altitudes by seeking air rising along ridges or in the form of columns called thermals, dynamic soaring provides speed or altitude by exploiting micro-lift and wind gradients—differing rates of movement in neighboring

"Jim Maupin never envisioned the Carbon Dragon being used this way.... [Dynamic soaring] arose after we started exploring with it."

—Gary Osoba

Fred Flintstone would approve: The foot-launchable Archaeopteryx toes the line between hang glider and sailplane. The prototype first took to the air in 2003, and its designers are now considering a production model.

ROBERT KAESER

air masses. "You're looking more to try to bounce off gusts of air and get energy from air that's much more complex than just [a thermal]," says Taras Kiceniuk Jr., a hang gliding pioneer who has done much to put dynamic soaring on a sound mathematical basis.

Dynamic soaring is not a new idea—"It's been postulated for over a hundred years," says Osoba—though it's gained some exposure in recent years through the exploits of hobbyists who pilot radio-controlled model sailplanes. By flying these gliders in oval patterns between the high winds just above a hill and the still air just behind it, they have been able to turn their sedate models—which normally fly at 25 to 40 mph—into screaming rockets that rip around at up to 230 mph, sometimes tearing their wings off in the process.

Seabirds have been dynamically soaring for untold eons. For example, albatrosses take off from the ocean's surface (with a lot of vigorous flapping and running on water with webbed feet), climb to a height of perhaps 30 feet, lock their wings, and thereafter soar back and forth between the near-stationary air near sea level and faster moving air higher up. Each time they rise into the fast moving air, they get a small energy boost that enables them, as they glide back down into the near stationary air, to travel hundreds of miles a day without flapping their wings.

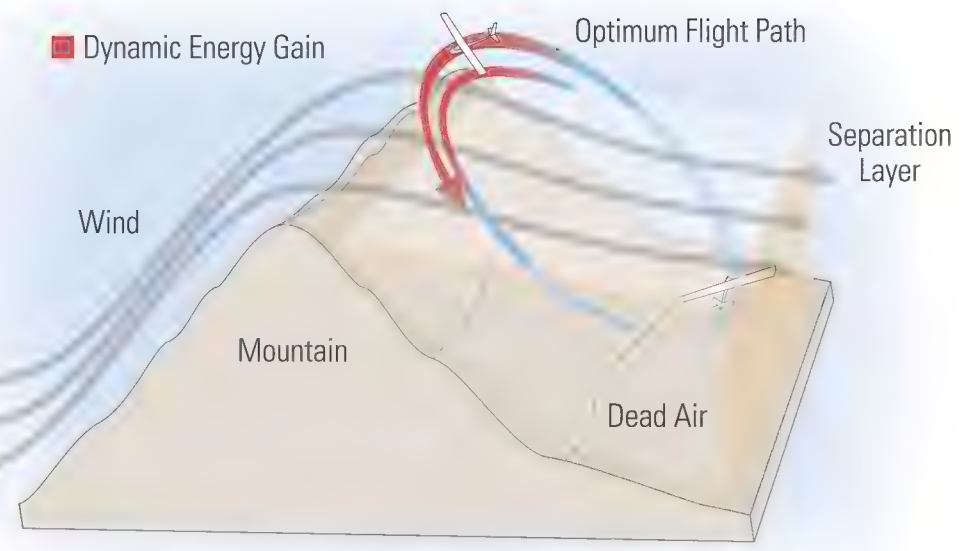
Although staying aloft with dynamic soaring requires considerable technique, its basic maneuvers are simple

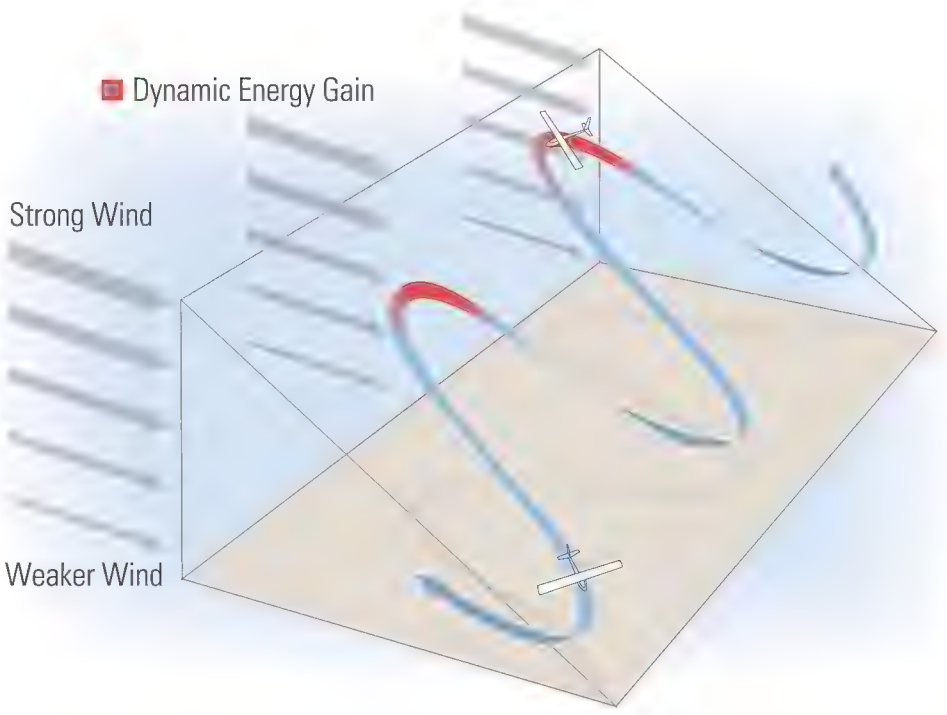
Jim Maupin (left) and a team of student volunteers glued together the first Carbon Dragon in the 1980s.

COURTESY SAILPLANE HOMEBUILDERS ASSOCIATION

How to Dynamically Soar

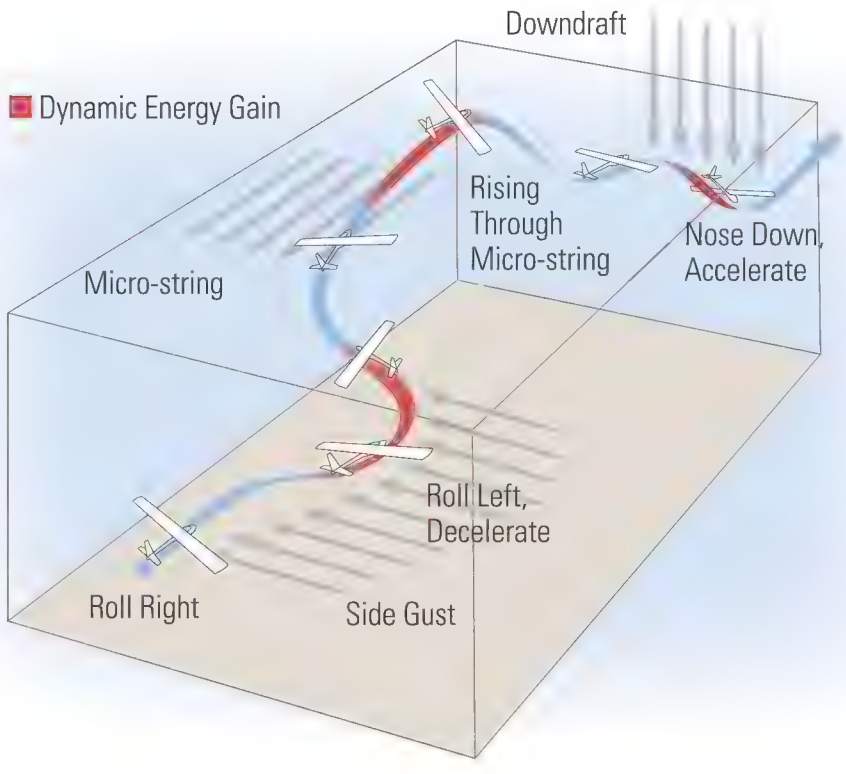
By flying a circular pattern between the wind flowing over a mountain and the relatively dead air behind it, a sailplane can continuously gain energy. Energy is gained at the top of the pattern, when the aircraft's belly and wings are turned to the wind to absorb a push. With each cycle—and push—the sailplane enters and exits the area of dead air with greater airspeed.





An S-turn technique can be used to exploit a wind gradient. Again, the sailplane gains a push by exposing belly and wings to stronger winds at higher altitudes. After a speedy descent into an area of slower winds, the pilot points the sailplane into the climb, thus converting kinetic energy (speed) into potential energy (altitude) as the sailplane soars upward for another push.

Dynamic soaring in micro-lift requires split-second maneuvering. A pilot turns sharply into a side gust and then banks slowly away to expose the sailplane's belly and wings to the wind's push. Just one wing is inserted into a micro-string, but the entire aircraft rises. A downdraft's energy can be absorbed by going into a zero-G dive. Downdrafts usually materialize and disappear too quickly to invert the aircraft.



ILLUSTRATIONS: JUAN THOMASSIE

enough: When encountering a gust of air, the pilot, instead of fighting to stay level, instantaneously banks to expose his sailplane's broadest surfaces to the wind and gain a push. Taras Kiceniuk explains it this way: If a sailplane is hit by a sideways gust, the pilot will immediately bank away from the gust, expose the belly and the bottom of the wings to it, and pull a couple of Gs. As the pilot finishes the maneuver and the sailplane's tail slips parallel to the wind, the downwash from the wings slows the gust, thus reducing the gust's energy while transferring that energy to the sailplane in the form of higher speed.

When the Carbon Dragon first appeared in the late 1980s, its balsa wood construction and dope-coated wings gave it the appearance of an oversize stick-and-paper model. But Gary Osoba, who started entering it in soaring contests in 1994, proved it was no toy; the sailplane could climb three to four times faster in thermals than other sailplanes and beat them on distance by margins of two to one. The Carbon Dragon could also get aloft two hours before other sailplanes could, and remain there much longer—usually until the sun went down or until, after seven, eight, or nine hours, the pilot had to relieve the pressure in his bladder.

Though Maupin's team finished the prototype in 1987, downturns in Maupin's health kept the craft grounded for most of the next six years. It spent just 10 hours aloft during that period, mostly gliding gingerly back to Earth from late afternoon car tows to a mere 300 feet. In 1989 Osoba saw photos of the sailplane in *Soaring* magazine and called Maupin to ask if he could buy it. For several years, Maupin declined (Osoba had no interest in building his own Carbon Dragon from the plans Maupin was selling), but in the summer of 1993 he relented and sold the prototype.

Osoba's first flight was a revelation. On an overcast afternoon with weak thermals, he realized how different this sailplane was. "I remember taking off and looking over to the right of the grass strip and seeing a red-tailed hawk sitting on a phone pole," he says. In the Carbon Dragon, he could stay up when even the hawks weren't flying. What's more, he's since found that takeoff rolls can be as short as five feet—even shorter if the wind is blowing strongly enough. All he has to do then is wait for a gust and pull back on the stick. In the right winds he has been able to settle the glider on the ground vertically, and on occasion land while drifting backward.

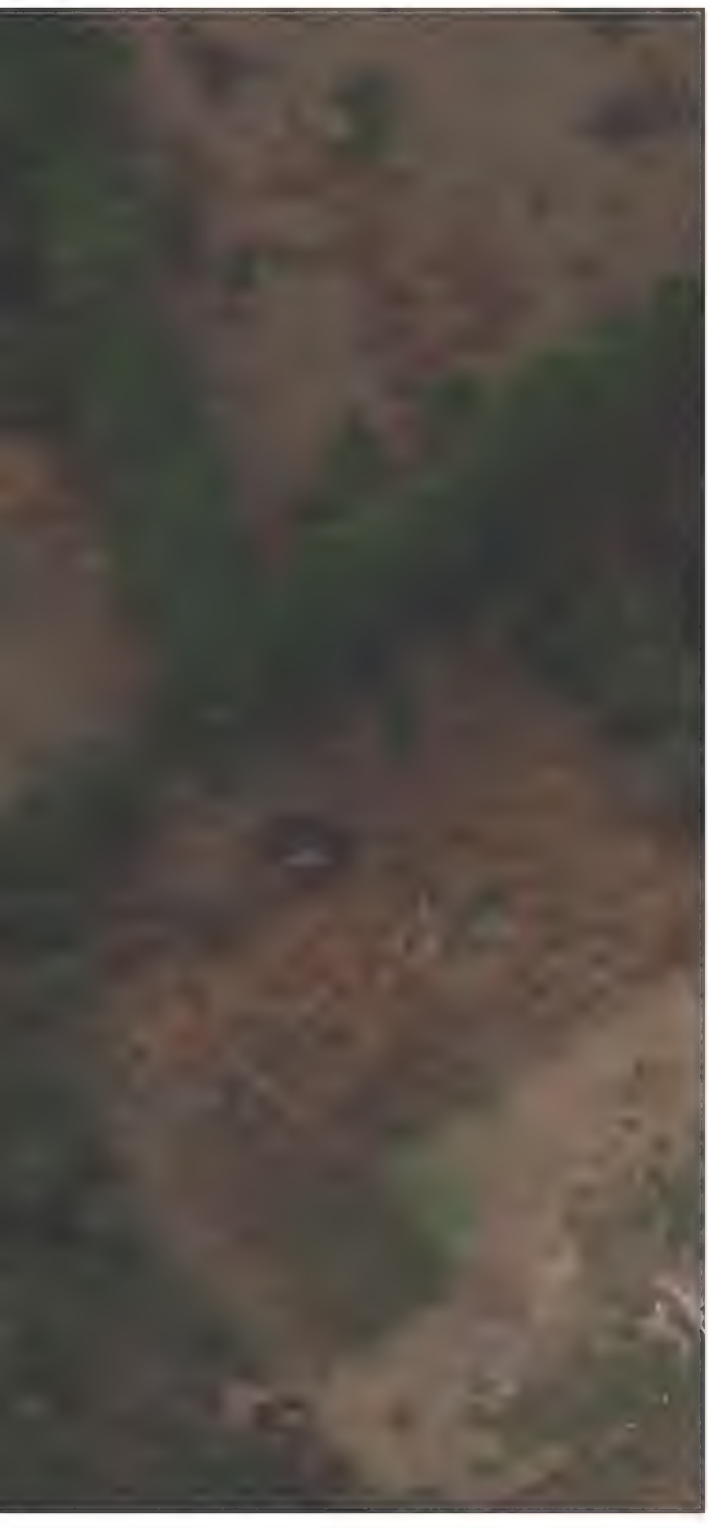
But by themselves, mere random gusts aren't enough to keep a micro-lift sailplane in the air. Micro-lift also comprises what Osoba has termed micro-strings—"thin, string-like animals that flow into thermals like a winding stream would [flow into] a lake." No more than a wingspan wide, these miles-long horizontal rivers of air can follow erratic paths and make abrupt turns. This is where the slow-flying Carbon Dragon really excels.

When he finds a micro-string, Osoba immediately slips gently into it until his one wing is completely inside. "You can rapidly roll into it and create 2 Gs on that wing relative to the other wing," he says. "Now it's not sustainable because you're not going to do a barrel roll.... What you do then is you roll back out of [the micro-string] at a more gentle rate into the relative sink and reaccelerate, and then you come back and you roll in and out, in and out of the edge of this shearing event, feeling your way along it." By continually slipping between the different air masses—essentially doing in a horizontal plane the same thing an albatross does in a vertical one—Osoba has been able

Right: Aerodynamicist Paul MacCready (left) and hang gliding pioneer Taras Kiceniuk are designing two dynamic-soaring-capable unmanned craft.

Below: Steve Arndt pilots his Magic Dragon, a heavily modified Carbon Dragon, near Orlando, Florida.

CHAD SLATTERY



RICHARD JOHNSON

to fly into the wind for as long as 20 minutes without losing altitude, and at times even gaining some. Osoba will even avoid looking at the ground or clouds for fear they will subconsciously influence his direction. At other times, he flies with his eyes closed to better sense the air. ("Jim Maupin never envisioned the Carbon Dragon being used in this way," he says. "[Dynamic soaring] arose after we started exploring with it.")

Because its long, lightly loaded wings act like a magnifying glass that enables the pilot to sense the slightest change in speed, pressure, or lift, the sailplane can also confer advantages on pilots who use it to soar conventionally in thermals. "When you cross the core you can feel it in your wings," says Osoba. "I would toss out a Kleenex and it would stay centered in the core. And I would just plant my wingtip, pointing it at the Kleenex and get tighter and tighter."

New Hampshire hang glider pilot Steve Arndt says his home-built Magic Dragon—he added winglets, stretched wings, and a graphite shell, and made other modifications to Maupin's basic design—can fly 80-foot-diameter circles in thermals, compared to at least 300 feet for a fiberglass ship. "It flies so slow in turns it looks like the inside wing is going backwards," he says. The small turning radius enables Arndt to fly wingtip to wingtip with vultures in rising air. "They're always looking for other soaring creatures," he says. "Once they get used to you, they'll fly right with you."

Osoba is now teaming with Kiceniuk and Paul MacCready to develop two unmanned aerial vehicles whose internal computers will be programmed to use dynamic soaring techniques to significantly extend flights—go faster, fly higher, or stay up longer. MacCready has made a career of designing aircraft that embody his unconventional ideas about low-power flight. His achievements include the human-powered Gossamer Albatross, which was pedaled across the English Channel in 1979 (it's now enshrined in the National Air and Space Museum's Steven F. Udvar-Hazy Center); the solar-powered Solar Challenger, which accomplished the same feat in 1981; and Helios, a solar-powered UAV that in 2001 flew to nearly 97,000 feet, snatching the altitude record for a propeller or jet aircraft away from the Lockheed SR-71 Blackbird.

Because building a Carbon Dragon is so labor-intensive (up to 3,000 man-hours or more), only nine are known to be flying worldwide. Just 10 others are under construction, and because Maupin's family stopped selling plans a few years ago, it's unlikely that many more will be built (though Steve Arndt says that old blueprints are available through the Sailplane Homebuilders Association). Even so, says Osoba, the Carbon Dragon's famous bloodline will never disappear. Designers in Chile, France, and Russia are building sailplanes closely modeled on it. And there's Danny Howell, who, when designing the LightHawk was inspired by some of the Carbon Dragon's best characteristics—though he's integrated newer technology such as composite construction, a laminar-flow airfoil, and upward-swept wingtips for better control at stall speed.

"For me, it's never been about going from point A to point B," says Howell, who as a teenager used to band hawks at Hawk Mountain, Pennsylvania. "It isn't about getting really high and it isn't about going anywhere as quickly as you can.... The whole idea here is to build a sailplane that can fly...slow, nap of the Earth, feeling the air.... That's what it's about—being a hawk."

How Things Work:

The Meat

by Sam Goldberg | Illustration by John MacNeill

To imagine landing on an aircraft carrier, picture falling 70 stories toward the ocean each minute with nothing but a glorified traffic light to tell you if you're on track to snag an arresting wire, or whether you're about to crumple yourself against the carrier's ramp.

Naval aviators know that traffic light as the Improved Fresnel Lens Optical Landing System. A pilot uses IFLOLS to discern his glide slope—the angle at which aircraft descend and land—by tracking the up-and-down motion of a "meatball," a bright amber light. The more closely aligned the meatball is with a horizontal row of green "datum" lights, the closer an aircraft is to its prescribed glide slope. (Coming in at too shallow an angle risks clipping the deck's edge. Landing too steeply busts landing gear.)

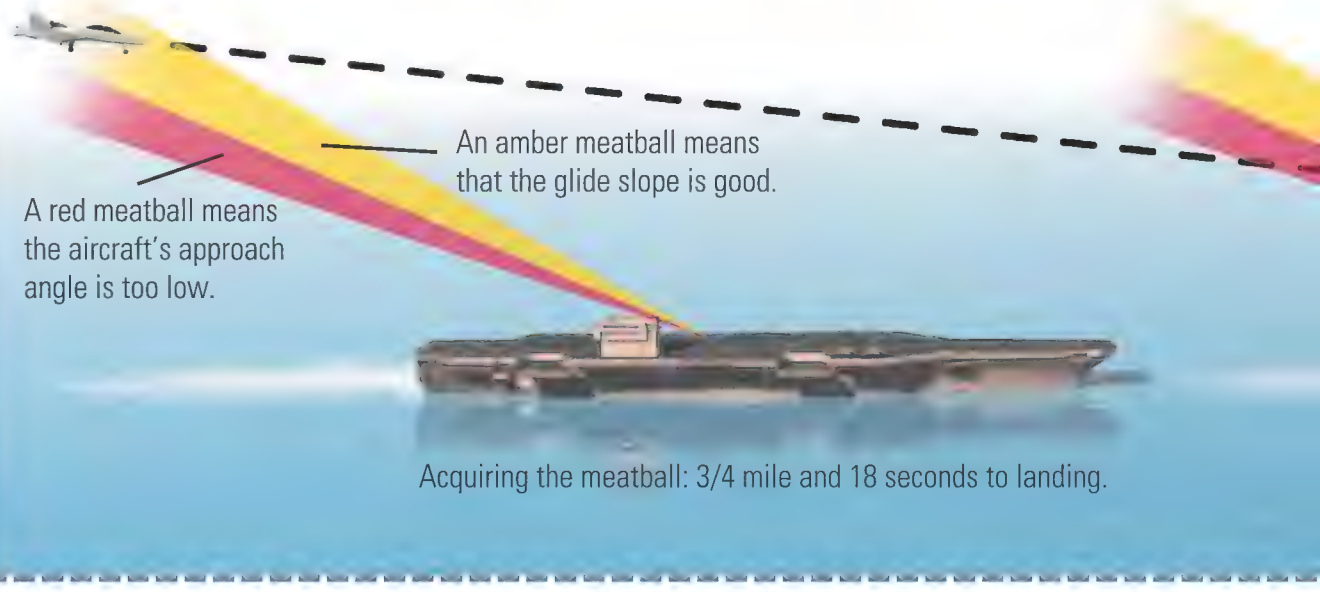
The IFLOLS unit generates its meatball through an optical trick: A stack of 12 light cells produces a single ball-shaped image.

Within each cell, a reflector focuses light through an interference filter that passes only a narrow band of wavelengths: amber in the top 10 cells, red in the bottom two. The filtered light enters a fiber optic converter, which makes it easier to focus, and exits as an intensely bright line, about 10 inches long and a fraction of an inch high. It then passes through a series of elements that act as precision magnifying lenses.

If you were to peer into one of the 12 IFLOLS lenses from a distance of 20 feet, the magnified line would look like a crisp bar of light about an inch high and as wide as the five-inch-diameter lens face. As you move farther away, the bar would grow vertically and its edges would begin to fuzz. Farther yet—at around 500 feet—the bar would grow so big it would fill the lens: This circle is what pilots recognize as the meatball. And because the light exiting an IFLOLS unit is nearly collimated (the light rays travel almost parallel to one another), the meatball a pilot sees from distances greater than a quarter-mile is about 7.5 inches in diameter.

George Bray is a naval engineer who helped design the IFLOLS optics in the late 1980s and 1990s. He explains that the 12 cells, stacked in a slight convex curve like a bowed pillar of flashlights, make a six-foot arc of what would be a 240-foot circle. The effect, he says, is to make pilots believe that when they look at the column of light cells (the lenses are separated by an inch), they are looking through a tall,

The IFLOLS (in circle) aboard the USS George Washington.

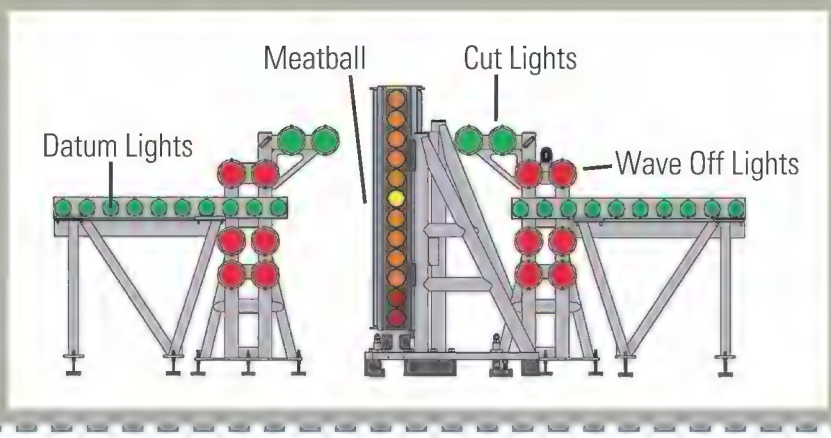


Acquiring the meatball: 3/4 mile and 18 seconds to landing.

ball

IFLOLS Configuration

An Improved Fresnel Lens Optical Landing System unit isn't all about the meatball. "Wave-off" lights flash if the deck is not ready for a landing. Coming in too low? "Cut" lights mean, strangely, add power.



slender window at a ball of light 240 feet beyond the row of green datum lights.

As pilots ascend and descend, different cells combine to form an image of the meatball. "For example, if you move up, you're gonna see it through the upper part of the 'window' [light cells closer to the top of the column]," says Bray. "If you move down, you're gonna start to see it moving through the lower part of the window." As many as three light cells or as few as one can be involved in producing the meatball.

At three-quarters of a nautical mile—the point at which daytime fliers turn for final approach and enter the "groove," the last 15 to 18 seconds of flight—the meatball can be seen over a swath of sky roughly 135 feet tall by 3,300 feet wide. At night, pilots have more time to make course corrections; aircraft approach the ship straight on from 10 miles out, and the meatball—which is about a quarter as bright as high-beam auto headlights—is easier to find against a dark background. "Depending on how good your eyes are, you can start to pick it up at a mile and a half," says Lieutenant Commander Joseph Krasinski, an F/A-18 pilot and the officer in charge of the Navy's Landing Signal Officer School at Naval Air Station Oceana in Virginia Beach.

If a pilot sees amber, he is seeing the meatball through the upper part of the IFLOLS window, and his wheels should hit the deck. But if the meatball turns pinkish or red—meaning he's seeing one of the bottom two cells—the poop deck is just seconds away, so he should pull up and peel off for a second try.

Under normal circumstances—average wind and seas—the ideal glide slope is centered at 3.5 degrees above the deck, which equates to 14.1 feet of clearance between aircraft hooks and the aft edge of the deck. But according to F/A-18 pilot Matthew Pothier, a former LSO school officer in charge, stormy seas can call for adjustments: "If the aircraft carrier is [pitching up and down] plus or minus 10 feet…that clearance factor starts to get a lot lower than 14.1 feet, because the lens itself—the meatball—is stabilized not to the aircraft's movement but to the horizon, basically. So we'll go ahead and adjust that glide slope up to four degrees. That's usually the maximum we'll land at, and that's going to give us more hook-to-ramp clearance, basically—a couple more feet."

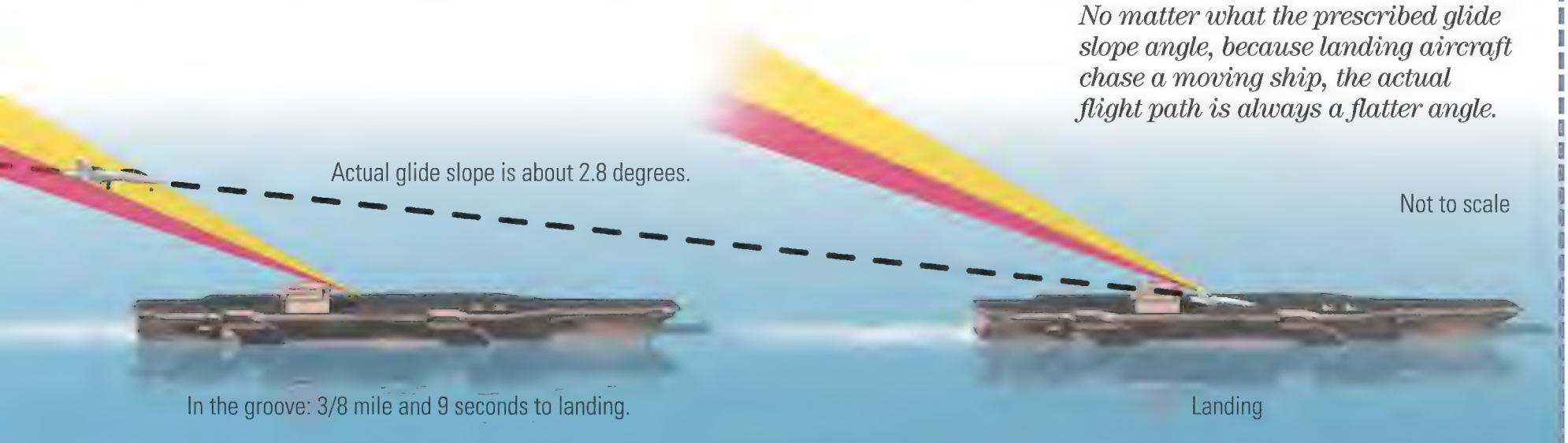
NAVAL AIR WARFARE CENTER (3)

With a low, six-foot profile, the IFLOLS unit allows wings loaded with fuel, sensors, and armament to easily pass overhead on takeoff.

Conversely, if winds are high, the glide slope will actually be lowered.

And if the glide slope is flown perfectly—"What we always want guys doing is flying the ball all the way to touchdown," says Krasinski—each aircraft's hook should smack the deck in the middle of the landing area's four arresting cables, between the 2- and 3-wires.

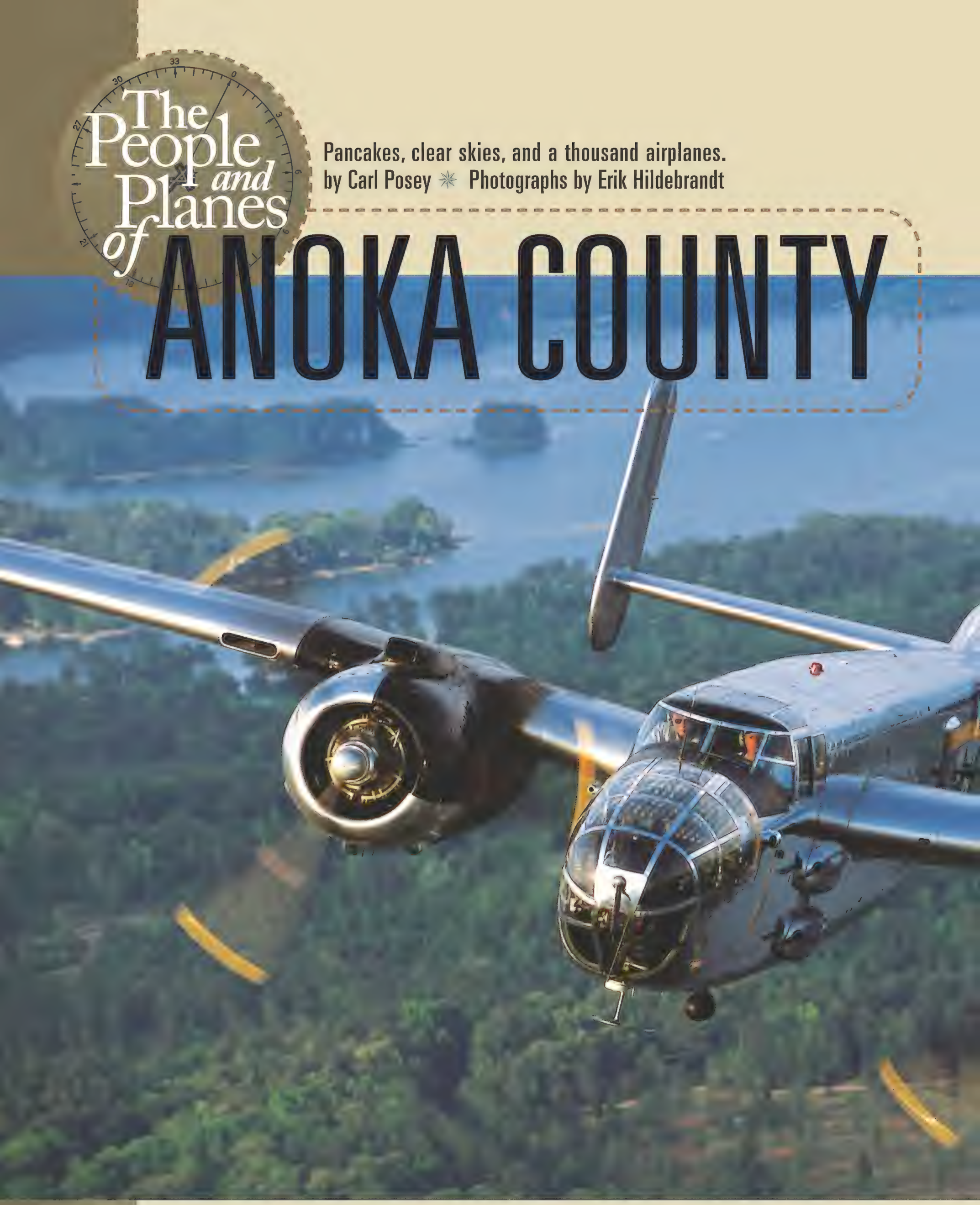
No matter what the prescribed glide slope angle, because landing aircraft chase a moving ship, the actual flight path is always a flatter angle.



The People and Planes of ANOKA COUNTY

Pancakes, clear skies, and a thousand airplanes.

by Carl Posey ✳ Photographs by Erik Hildebrandt



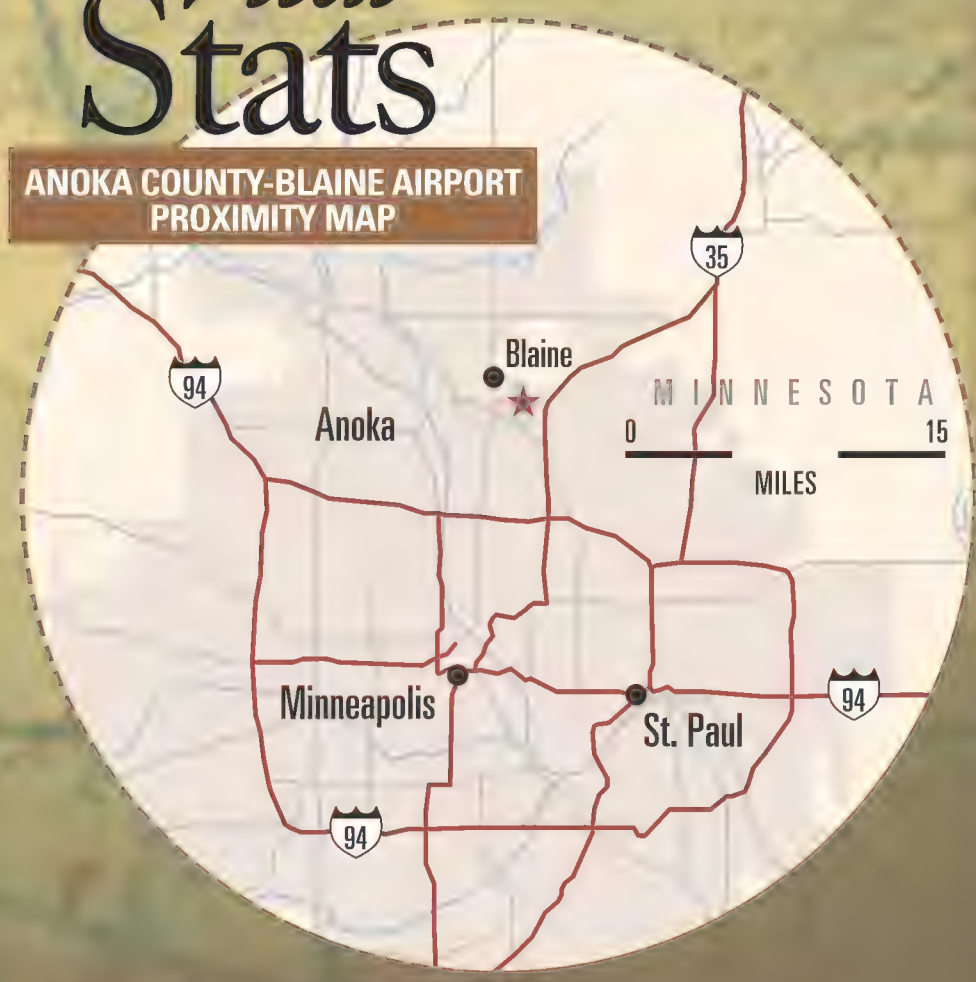
Airplanes at Anoka in various stages of airworthiness include a pristine North American B-25 (above) and works in progress like a Cessna L-19 and O-2A and a Grumman OV-1 Mohawk (right).

Although just half an hour north of central Minneapolis, Anoka County-Blaine Airport looks less like a suburban airport than a remote Scandinavian village: a bit severe, clean as a whistle, cheerfully bland. The setting is not unlike the Minnesotan scenes in Garrison Keillor's imaginary Lake Wobegon, with its community of distinctive characters. It is not immediately obvious, for example, that the residents of this little city of pastel hangars are extraordinarily single-minded about aviation, or that, while most of them have other lives, they seem to think the life at Anoka County-Blaine is the one that really matters.

The airport stays open year-round—airplanes like the Minnesota winter's dense, stable air—but it quiets down in the cold months. One resident pilot notes that the runways are kept clear and you can fly all winter—but you can freeze to death prepping your airplane.

The arrival of reasonably warm weather is celebrated with Discover Aviation Days, held the penultimate weekend in May. Warbirds, vintage civil aircraft, and homebuilts arrive for aerobatic displays, helicopter and open-cockpit rides, and tri-motor sorties. Hundreds of hangars decant their eclectic collections—a squadron of Russian jet trainers and a fighter, another of North American B-25 Mitchell bombers, yet another of T-6 trainers, a flock of slow-flying

Vital Stats



ANOKA COUNTY-BLAINE AIRPORT (ANE) is 10 miles north of Minneapolis and is on the Twin Cities sectional chart. Watch out for deer, waterfowl, and Russian jet trainers. Anoka, a "reliever" airport for Minneapolis-St. Paul International, averages some 400 takeoffs and landings a day.

military liaison aircraft of yore, interspersed with ghosts from the Golden Age of Aviation and tiny, swift homebuilts.

DAD, as the fete is called, evolved from a pancake breakfast established two decades ago by Anoka's Experimental Aircraft Association Chapter 237. In recent years, the crowds have topped 25,000. DAD proved such a success that in 2003, the event was incorporated. The following year, the army of volunteers marshalled for the event expected 40,000 visitors.

CAROLINE SHEEN

A Piper L-4 Grasshopper demonstrates the Brodie System, in which an aircraft snagged a trolley that ran along a cable in order to land on a short strip or a ship.

Last May, however, the Minnesota weather ambushed DAD, thinning crowds with cold wind and rain. No warbirds flew in; now and then one could be heard above the overcast, approaching, then giving up, the growl receding. Candy-striped tents and kiosks set up along the flightline offered hamburgers, corn dogs, foot-longs, and caramel corn. There were tents for Pilots for Christ International, for the EAA, for the Air National Guard, with its cutaway C-130 Hercules cockpit, and for the usual vendors of aviation memorabilia.

A trio of pristine warbirds—two B-25s and a Convair L-13A—were trundled out for display. When the ceiling rose slightly, the L-13 began shooting stately touch and go's, joined by a tundra-wheel Super Cub, then a minuscule buzzing homebuilt, then a yellow and blue Stearman PT-13. Three Russian jets—a couple of L-29s and an L-39—were towed across the field and tied down next to a pair of T-6s. In a nearby ring, the Piston Poppers' tethered models swarmed like bees.

Saturday night's Divine Swine pig roast didn't attract many takers. But by the time the Fourth Annual Hangar Dance rolled around, 500 or so celebrants, dressed like extras in a 1940s film, had braved the elements to gather around tables with small American flags. Then, lulled by Dave Andrew's Big Band, they settled happily into a past not all of them were old enough to remember.

Anoka County-Blaine Airport is also known as Janes Field, after the late Phillip Janes, a former Navy pilot who directed the Federal Aviation Administration's General Aviation District Office and later worked with the Metropolitan Airport Commission for many years. The airport identifier is ANE—Janes with the J and S removed—but on the radio it's just "Anoka Tower" and "Anoka Ground"—unless you're an out-of-towner. According to airport manager Joe Harris, the number of Minnesota-registered aircraft calling Anoka home is 544, but some residents believe the airport hosts a thousand airplanes (though not all are airworthy).

The first tenant was Daniel F. Neuman, who in 1953 bought a hangar on the southwest side of the field. After 37 years of flying for Northwest Airlines, seven of them as a Boeing 747 captain and instructor, Neuman retired in 1978. Now, at 86, "I still pass my physical, still fly, I'm still doing what I love to do."

Neuman does what he loves in an old hangar filled with neatly filed books and blueprints. Occupying much of the space is a 1929 Waco 10 fuselage frame, freshly sheathed

in Irish linen. "It's the third one I'm rebuilding," Neuman says. "I've rebuilt a number of planes. Usually when I get through I sell them." At the moment, he flies a 1980 Beechcraft F33A, a Buhl Bull Pup, and a 1938 Stinson SR10 Reliant.

Anoka is also home to Greg Herrick's Golden Wings collection, which comprises about 40 of aviation's rarest craft. Herrick settled on the Golden Age of Aviation as a pilot and collector, but his interest goes far beyond owning and using a priceless work of flyable art. For example, he doesn't see the Fleetwing Seabird as just a shining amphibian with a big radial engine atop its high wing. He sees a relic of an era when manufacturers were choosing a metal with which to cover aircraft. The Seabird is all stainless steel, built for imperviousness to rust, even in the sea.

The collector values the back stories of his airplanes as much as the machines themselves: the Arrow Sport designed for the 1930s Bureau of Air Commerce's Everyman's Airplane competition; the 1935 Waco Wind Harp, considered the Learjet of

CAROLINE SHEEN

As many as 40,000 visitors can turn up for Discover Aviation Days, Anoka's celebration of the arrival of spring. The B-25 Miss Mitchell *always draws a crowd.*

CAROLINE SHEEN

Greg Herrick (at right), amasser of the Golden Wings collection of rare aircraft, has a pre-flight chat with Jim Obowa, who occasionally takes Herrick's 1931 Stinson Tri-motor for a spin over the fields around the airport (below).

the 1930s, that ferried gamblers to Havana; the replica of Amelia Earhart's Avro Avian biplane; the Kreutzer tri-motor retrieved from a mountain strip in Mexico. The only thing Herrick likes better than telling their stories appears to be flying them (see "The Magical History Tour," Aug./Sept. 2003).

The unwritten rule at Anoka County-Blaine: If you see a car outside a hangar, you're free to go in and visit, borrow a tool, seek some advice, and, if the hangar is Dan Neuman's, have a cup of tea. On this day, Neuman hands a bulky case to the visiting Greg Herrick. Inside is a set of World War II-vintage Japanese naval binoculars. Herrick is clearly charmed by the gift, but protests. Neuman waves away the objections: "You're always giving me stuff. Thought I'd reciprocate."

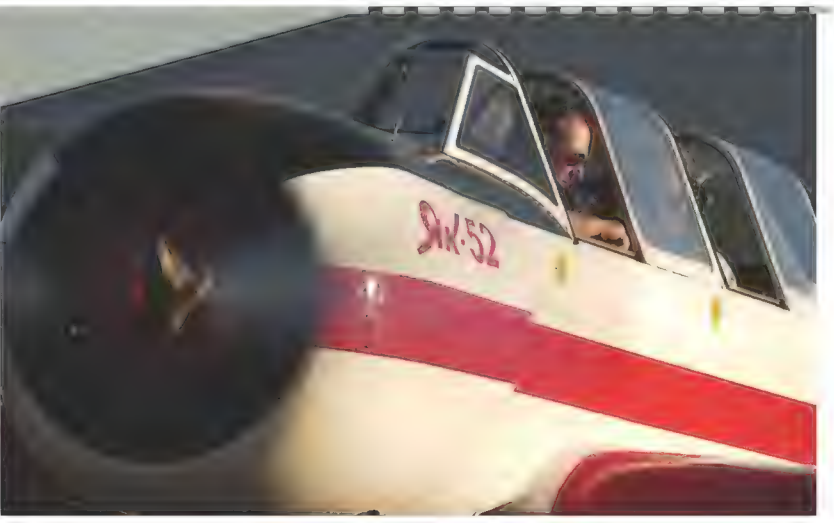
At Anoka-Blaine, homebuilts constitute a large part of the mix. Gary Specketer, a noted crafter of homebuilts who is active in the EAA chapter and a principal in the Anoka County Airport Association (basically a hangar owner's group), has built a Dragonfly and a GlaStar, finished a Van's RV-4, and helped colleagues with GlaStars and Glasairs. He flies a Glasair III he built 16 years ago that looks as fresh as one of Herrick's Golden Agers. "You build a homebuilt either to get performance you can't buy, or an airplane you can afford," he says. He says his rocketship gives him 295 mph cruise—southern Florida is five and a half hours away, he says, and five more to the Virgin Islands. But now he's thinking about selling it and building a Van's RV-10.

He also employs his expertise as a technical counselor for the EAA. "The big question when you haven't built before is: What do I spend time on? The counselor gives shortcuts, warns of misdirection. There are 500 to 600 EAA counselors. The FAA won't inspect a plane if you haven't had a counselor inspection."

Nancy Carter, current president of EAA Chapter 237, presides over the airport's weekend pancake breakfasts, chatting with colleagues and accepting the occasional $20 dues from new members. "We're very active," she says. "We have about 50 builders in our group. Some are on their third plane. Most of them have at least a couple of airplanes." At the EAA Christmas party, plaques are awarded to members who have completed projects. Most years there are three or four, some years as many as 13.

Carter joined the EAA in 1996. "I started to build a plane—a DR-109, two-seater aerobatic," she says. "The airplane's still in

Dan Neuman (left), Anoka's first tenant, bought his hangar in 1953. His current restoration project is a 1929 Waco 10. Air & Space *contributor Erik Hildebrandt (below) washed Anoka warbirds to get his foot in the hangar door. He restored this Cessna L-19E and is working on an O-2A.*



Anoka's Russian aircraft specialist Doug Weske prepares to test fly a local Yak-52.

my basement." The man responsible for her having an airplane in her basement, she says, was the late Mike Langer, a former Mohawk pilot in Vietnam. "He was the kind of person who encouraged dreams. I was living in an apartment. Then I ended up having the house built, a walkout with double doors because of the plane. Right now I have wings in the basement."

Another thing Langer made happen was the American Wings Air Museum, at the north end of the flightline, next to the control tower. "Mike and I had worked together since the mid-1970s," says museum director Len Burgers. "He happened to find the serial number of an A model Mohawk he'd flown a lot in Vietnam. Brought it back to a T hangar—then, in December '85, began moving stuff here. In the meantime he'd been talking with Grumman and the Army. To restore it required more support from them. They said they'd be glad to help except we weren't a museum. So we started doing the paperwork. Started acquiring Mohawks. We once had 14. We opened November 1997. Mike died April 1998." Langer's Vietnam Mohawk has been in storage since his death.

American Wings has lent floor space to the Minnesota Air & Space Museum, which has no home, to restore a 1911 Steco Aerohydroplane. The project feels more like archaeology than aircraft restoration.

The only airplane built by Stephens Engineering Company (hence "Steco") was flown a few times off Lake Michigan, then packed away in crates and left in a Chicago garage. Three-quarters of a century later, Dennis Eggert, the president, recovery team captain, and chief mechanic of the Minnesota Air & Space Museum, came upon the remains and opted to restore the Steco.

While the provenance of the aircraft was known, its design contained some mechanical puzzles. For example, directional control came from a movable empennage, not from rudders, ailerons, or warpable wings. "We finally figured out that Stephens was trying to get around the Wright brothers' wing warping," says Eggert. "He wanted to compete for aeronautical patents."

Having gained possession of the Steco, and one of Stephens' 1909 cars, the homeless museum was forced to put the crates back in storage. Then, in 1998, the relic was lent out to be restored for the Heritage Halls Museum in Owatonna, Minnesota. When that didn't work out, Eggert and colleagues retrieved the aircraft, disassembled it, and shipped it back to Blaine, where American Wings Air Museum offered 1,600 square feet of floor space.

That was in the winter of 2002. Since then, the Steco has been gradually metamorphosing into what the restorers believe was its original form. Last June, Eggert ran up the Steco's Gnome Omega rotary engine half a dozen times. "It started beautifuly each time," he says. In time, Eggert hopes to wheel the whole machine out, its "first time in daylight since 1914."

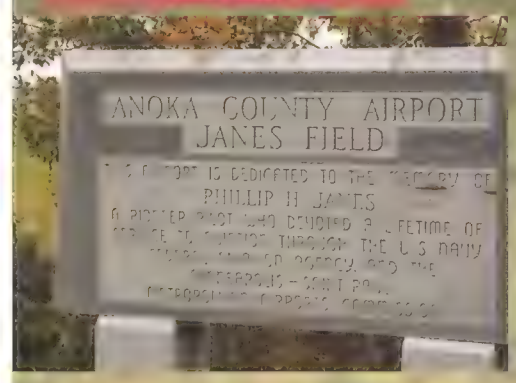
A few businesses reside happily at Anoka-Blaine. Dan White runs a restoration shop. Today he's winding up some work on Herrick's Stinson Model A tri-motor, a low-wing monoplane wearing old American Airlines livery. "It took a guy seven years hauling the airplane out of the forest, using a Caterpillar and big skid," says White.

White is in the middle of restoring seven Super Cubs, building new ones, and finishing up a Howard DGA. He learned the restoration art by rebuilding a Stearman for

Patrick Harker displays an inspection cover from his restoration du jour, *a North American P-82 Twin Mustang.*

Fun Facts

ANOKA COUNTY-BLAINE AIRPORT



Don't Miss:

Anoka's traditional Discover Aviation Days weekend celebration will differ this year, primarily due to a lack of funding after DAD 2004 was weathered out. All are invited to Blaine Aviation Weekend, May 20–22, which will kick off Friday evening with a hangar party at the Golden Wings Museum, hosted by the Lindbergh Foundation, with Burt Rutan of SpaceShipOne fame as the featured speaker and Erik Lindbergh as master of ceremonies. The weekend includes a fly-in, warbird roundup, and pancake breakfast at the American Wings Air Museum. Visit *discoveraviationdays.org.*

Dan Sullivan says his Eastern bloc L-39 jet trainer (above), as well as his L-29s, "are good at low speeds; still, they can get away from you. It's easy to pull 4 to 6 Gs in these planes." He also flies a MiG-17—and for a change of pace, a Super Cub and a Cessna Caravan on floats.

CAROLINE SHEEN

The late Mike Langer (above) established at Anoka the American Wings Air Museum, which at one time had accumulated 14 Grumman Mohawks. Elizabeth Strohfus, a former Women Airforce Service Pilot, holds a museum audience rapt.

himself. How many airplanes has he done all together? "Oh my gosh," he says, "probably 25 Cubs, over 20 Stearmans, then all these one-of-a-kind airplanes for Greg. Over a hundred. We can do anything. Most of the stuff that comes in doesn't usually fly in. One guy brought in almost a whole airplane in garbage bags. A lot of this stuff is done strictly from blueprints. People bring me plans, I build the airplane."

Helping White is 27-year-old Melissa Lund, who, he says, "is good on the English wheel," which they use to roll sheet metal into complex contours like cowlings and wing panels. She did the Kreutzer tri-motor's cowlings, which look like hammered silver.

In one of the smaller, older hangars, Mike Rawson, a compact, bearded man, is restoring an A-25, a rare Army version of the Navy's Curtiss SB2C Helldiver. "The first bunch of fragments came out of Lake Washington, in Seattle," Rawson says. "It's the only one in the world right now. Hoping to finish it in three months." It will be airworthy, but it will fly only as cargo en route to the Air Force museum in Ohio.

Patrick Harker, resident prodigy at Anoka County-Blaine, presides over the aircraft at C&P Aviation, another restoration shop housed in a huge structure that locals call the Cargill Hangar, after its corporate owner. This laid-back, 30-something connoisseur is said to be the kind of craftsman who finds tools that are no longer used to do things that are no longer done on

airplanes that are no longer built. And what he restores, he flies.

On the gleaming floor sit a restored 1951 Grumman Albatross, a burnished aluminum L-13A with a wooden prop grained like a fine piece of furniture, a couple of Russian jet trainers, and a 1941 Waco UPF-7 biplane restored by Dan White. In a further cavernous room, a rare Boeing L-15 Scout, one of only a dozen built, waits to be recalled to life. The major work in progress is a P-82 Twin Mustang, which Harker figures will take him three years. "North American airplanes are easy to work on," he says. "No fancy stuff. A Mustang, T-6, B-25—all have similar features."

Doug Weske and his father, Paul, have fashioned another kind of warbird nest: a center for Russian L-29s and L-39s—jets that have won the hearts (and wallets) of American pilots. Paul Weske struck up a relationship with a retired colonel in the Russian air force and began importing L-29s. Now "people come here from all over for Russian airplanes and parts," says Doug. "There are eight L-29s on the field."

One of the L-29s at Anoka-Blaine belongs to Dan Sullivan, who is less a collector than a man with a keen interest in machines that are fun to fly. His office, a well-appointed mezzanine above his hangar floor, overlooks two Russian trainers, a MiG-17, a Piper Seneca, and a Super Cub with tundra tires. "I'm in the medical device business, make catheters and things," he says. "Do something nice for people, make money, waste it on jet fuel."

Sullivan learned how to fly in college and stayed with it through the years. Like most of the warbird owners here, he was never a military pilot. "I learned in the '90s they were selling Soviet airplanes. Bought an L-29. Someone taught me to fly it. Went down to a convention and someone showed me an L-39." He shrugs happily.

"For the MiG-17, I brought a major over from the Polish air force to restore it to perfect specs. If they'd let me buy an F-18 Hornet and I had the dough, I'd buy it." In 1998 he took his L-39 down to Naval Air Station Cecil Field in Florida and flew with some Navy pilots, who reciprocated by letting him fly the fighter.

Airports are small societies, and it's only natural that at times some unease arises between those with Russian jets and Mitchell bombers and those with an unfinished Pietenpol in a garage. Nor is wealth the only difference among the various tribes on this field. Warbirders are mainly metal guys, homebuilders mainly fiberglass. People immersed in the varnishes and stains and fabrics of an earlier era don't like the itchy fibers. Homebuilders prefer sculpting seamless forms from glass to cranking metal on an English wheel. Hardly anyone from the warbird and Golden Age tribes appears in the roster of EAA chapter 237, although there is the rare crossover—someone who built a Kitfox, say, but flies a T-6. These days such stuff doesn't seem to matter much, nor does what a person flies, or how many airplanes are in somebody's hangar. They are all passengers aboard the time machine known as Anoka County-Blaine Airport, where all the pilots are above average, and all the airplanes are good-looking.

When Mike Rawson completes the Curtiss A-25 Helldiver, the Army version of the Navy's SB2C, it will be airworthy, but it will fly only as cargo aboard a transport to the Air Force museum in Dayton, Ohio, where it will go on display.

SIGHTINGS

FRED BRUENJES

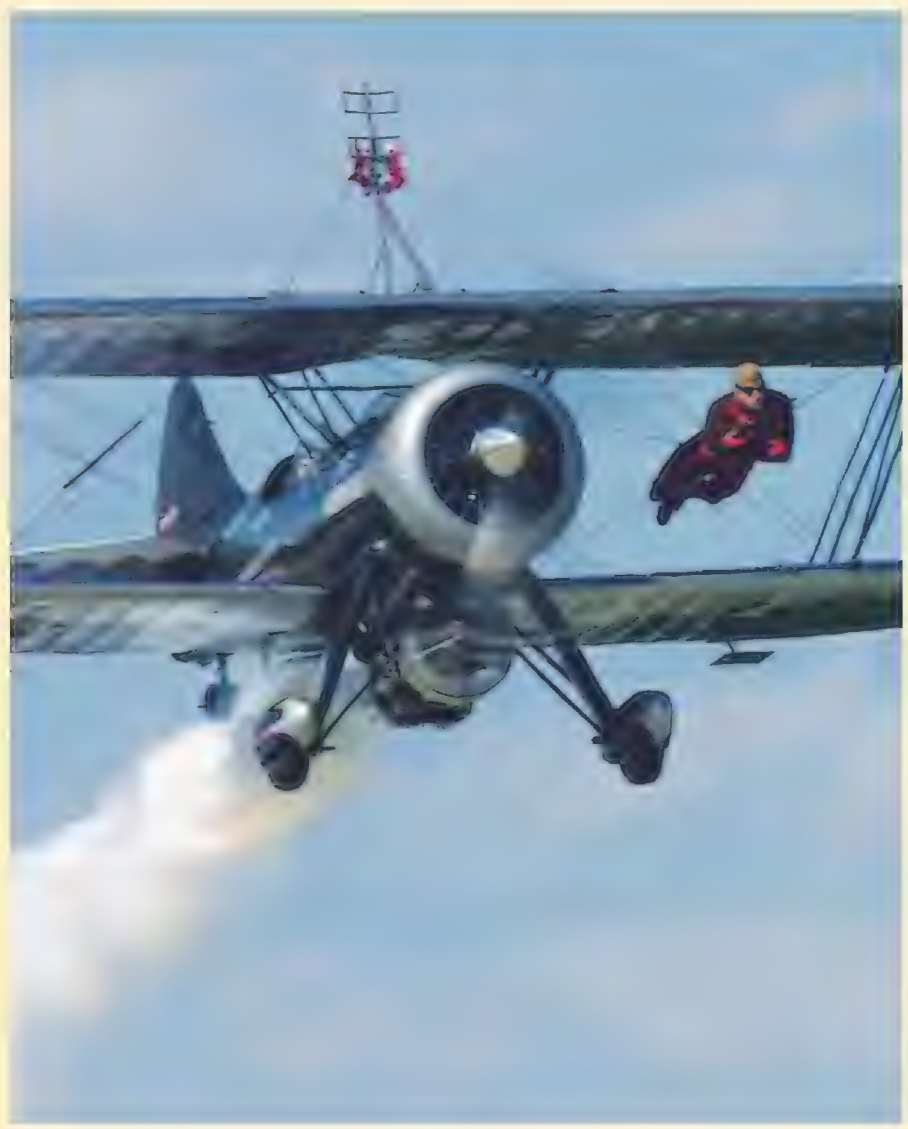
Each year, at airfields from Abilene to Westfield, from early spring through late fall, people gather by the thousands to watch their favorite airplanes flip, twist, and spin. In static displays on airport ramps, military hardware towers over homebuilts that sit alongside vintage aircraft. No matter which airshows you attend this season, you're bound to encounter at least one of these familiar scenes.

The show schedules combine a little bit of everything, from the sublime to the sinister: an ethereal glider—Bret Willat's *Sailplane Magic*, a Grob G-103 Acro—shares the runway at the Miramar Air Show in San Diego, California, with the alien F-117A stealth fighter (above).

No airshow would be complete without the gravity-defying stunt work of aerobatic pilots like Jimmy Franklin, who straps a General Electric CJ610-6 jet engine (and his son, wingwalker Kyle Franklin) to his 1937 Waco biplane (right). Similarly stunt-happy Gene Soucy has mounted a smoke system to his singular Show Cat biplane (opposite), a specially modified Grumman Ag Cat. Honest, that's Gene and the Show Cat beneath the smoke; you can tell by the orange and yellow wings.

The magic of flight is hardly wasted on the young, who accompany their equally wide-eyed parents to the flightline. Often, as is the case with Skyler Parsons (above right), the opportunity to meet a legend like Chuck Yeager is the motive to get to the show as soon as the gates open, pen and paper—and camera—in hand.

DON PARSONS



TYSON RININGER

RICHARD VANDER MEULEN

NASA

Before Boeing and Lockheed submitted their designs for the Joint Strike Fighter, the Air Force developed the SHARC concept vehicle to study unconventional control of flight.

Fighter Tactics

Ultimate Fighter: Lockheed Martin F-35 Joint Strike Fighter

by Bill Sweetman. Zenith Press, 2004. 160 pp., $34.95.

At around $200 billion, the contract for the Joint Strike Fighter was the Pentagon's biggest ever, and it touched off an epic five-year battle between Boeing and Lockheed Martin. At stake were the futures of the two aerospace titans and the fate of the world's fighter market for decades to come. The government's JSF specifications posed formidable engineering challenges: Build a fighter so advanced it would virtually fly itself; make it so versatile it would satisfy the combined needs of the Navy, Marines, and Air Force; bring it in for about a third of the cost of the state-of-the-art F-22 Raptor; and, trickiest of all, solve the thorny problems of controlling vertical lift in a supersonic, short-takeoff-and-vertical-landing design.

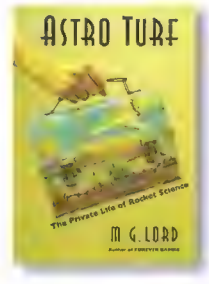
With a keen eye for irony and telling detail, aerospace journalist Bill Sweetman, a frequent contributor to *Air & Space/Smithsonian*, traces the origins of the JSF and STOVL back to the Harrier and its forerunners. He gives a blow-by-blow account of the design teams' rivalry as they struggled with mechanical glitches, parts shortages, and ever-tightening deadlines. Boeing's team opted for simplicity by relying on direct lift from the engine, but that made it more difficult to accommodate every pound of weight added as Pentagon requirements grew. Meanwhile, Lockheed Martin engineers solved the STOVL challenge with a liftfan, but its complexity led to frequent, unnerving breakdowns and the ignoble nickname "Chitty Chitty Bang Bang."

Ultimate Fighter is lushly illustrated and includes substantial coverage of the stealth and information technology of Lockheed Martin's winning F-35 design. Sweetman has spent years reporting on the JSF for aerospace periodicals, and his authority on the subject is clear. But this is not a definitive account; he stresses that the JSF story is far from over. Mounting costs, weight gains, and reluctance to give away too many stealthy secrets may make the F-35 less of a competition killer in the marketplace than originally hoped. In a shifting strategic world of insurgency and unconventional warfare, the JSF's value as a first-attack aircraft is open to question. Sweetman concludes that "the next few years look more than interesting for this ambitious airplane."

—Evan Hadingham is the senior science editor of the PBS series "NOVA." He wrote about the JSF competition in the Dec. 2002/Jan. 2003 issue.

Astro Turf: The Private Life of Rocket Science

by M.G. Lord. Walker & Company, 2005. 249 pp., $24.



At each turn, *Astro Turf* rages against The Man. The narrative skips between author M.G. Lord's experiences as the daughter of an emotionally distant low-level engineer at NASA's Jet Propulsion Laboratory and a work culture's oppression of women, gay people, and suspected Communists during the space race.

Lord's descriptions of the cold-war-era chauvinism at JPL are eye-opening. She includes stories of gay employees who were forced to out themselves to keep

their jobs; the disappointments and triumphs of women like Mars Exploration manager Donna Shirley; and smaller battles, like that to establish an on-site daycare center. The author also ponders how the United States could overlook the horrific past of the Germans it culled to father its space program, while at the same time committing crimes against its own loyal scientists (Lord focuses on intrusions into the life of left-leaning U.S. missile pioneer Frank Malina).

Of course, *Astro Turf* is in part the author's personal journey. Much can be inferred about Lord when she tells us that she no longer goes by her given name, Mary Grace, because of her idolization of the strong female characters in Robert Heinlein's science fiction. And passages about her lifelong struggle to relate to her father—which inspired the book—are well constructed but at times indulgent.

Lord's intimate style results in a book that sometimes feels like a diary, sometimes like a *60 Minutes* exposé that has turned up hidden details of a shameful past. But *Astro Turf*'s bite comes from the mere mention of details—JPL's Miss Guided Missile pageant; its scientists' belief that acidity in the skin of menstruating women could harm electronic components—that seem irreconcilable with American life in 2005. Unfortunately, during the last third of the book, tired passages such as "One can easily interpret a launch as a symbol of masculine power. It involves a potent object penetrating the heavens" cheapen an otherwise successful account of The Man's many offenses.

—Sam Goldberg is an Air & Space *associate editor.*

NEW SOFTWARE

Keyhole 2

Light version, $29.95; Pro (which lets you import imagery and make flyover movies), $599. Free 7-day trial from www.keyhole.com.

NASA World Wind

Free from worldwide.arc.nasa.gov.

Hey, I can see my house from here! For years, satellite photography gurus have promised the revolution. One day (always soon) we'll be able to explore Earth from our desktops, flying over a virtual planet rendered so accurately that Rand and McNally would be agog.

The future has arrived. Two new programs, *Keyhole* and *NASA World Wind*, come very close to fulfilling the promise by letting you zoom from Earth orbit down to your neighborhood, your house, even your car. If you have a broadband Internet connection and an up-to-date PC (sorry, Mac users), high-resolution photographs taken from airplanes and satellites will stream onto your screen almost as fast as you can point your mouse anywhere on the globe.

On my *Keyhole* test drive, I zeroed in on my childhood home near Washington, D.C., which, like most large metropolitan areas, appeared in color, with resolution good enough to make out the flower beds lining the sidewalk. I tilted the view to a flyover and went riding down the street where I used to deliver papers. Very cool.

Cambridge, Massachusetts, at Keyhole*'s peak resolution: three inches.*


NASA World Wind *reconstructs Fremont, California, from aerial photos compiled by the U.S. Geological Survey.*

NASA's free *World Wind* program doesn't have the high-resolution aerial photography, but makes up for it in coverage. It's better than *Keyhole* for rural areas and less populated parts of the world, pulling from medium-resolution Landsat and other space images.

The existence of these photos (which are typically a couple of years old, depending on when the satellite or airplane took them) is not new. You can find them on Web sites like *www.terraserver.com* and *www.terrafly.com*, or you can buy the higher-resolution (hence pricier) aerial photos from companies like AirPhotoUSA. But who needs to, when tools like these are becoming available? And now that Google has bought *Keyhole* (with undisclosed plans to incorporate it into the company's scheme to dominate the info-world), who knows what's coming next?

—Tony Reichhardt is an Air & Space *consulting editor.*

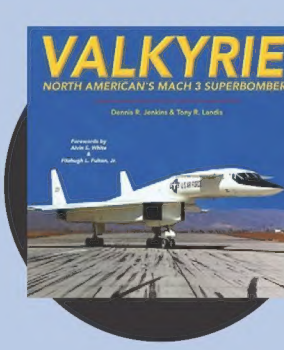
SHORT HOPS

Frau Im Mond

directed by Fritz Lang, 1929. DVD, Kino Video. 169 min., $29.95.

An eccentric professor theorizes there's gold on the moon and a plucky scientist battles industrial espionage and a romantic triangle to prove him right. That's the premise of director Fritz Lang's *Frau Im Mond* (The Woman in the Moon), a 1929 silent film long available only in truncated form. Kino Video's newly restored version is not for everybody, but space buffs will find items of interest. Pioneer rocketeer Hermann Oberth was the film's consultant, and the movie includes the first launch countdown, a multi-stage rocket, and weightlessness. Lang's foresight wasn't 20-20, though: His astronauts explore the moon in street clothes.

—Tom Huntington



Valkyrie: North American's Mach 3 Superbomber

by Dennis R. Jenkins and Tony R. Landis. Specialty Press, 2004. 264 pp., $39.95.

This book documents not only the history of North American Aviation's ill-fated B-70 Valkyrie supersonic bomber, but also the remarkable period during which it was developed. The narrative begins with the early days of work on supersonic and nuclear-powered bombers and continues with the exciting and sometimes terrifying test flights, tales of the Valkyrie's tremendous speed, and stories of the brave pilots who flew the only two Valkyries ever built. B-70 enthusiasts will enjoy little-known details of the short-lived program, as well as never-before-seen photographs and technical sketches, while reading what certainly seems to be a complete history of this fascinating aircraft.

—Bettina Chavanne

CREDITS

A Navy Brat at Pearl Harbor. Arthur Lee taught courses at Embry-Riddle Aeronautical University and retired from the U.S. Navy with the rank of commander.

Einstein's Wing. A mechanical engineer by profession, Nick D'Alto writes on science and technology for various publications and has built several replica aircraft for the Cradle of Aviation Museum in Long Island, New York.

The Space Shuttle Returns. Linda Shiner is the executive editor of *Air & Space/ Smithsonian.*

Despots Aloft. Von Hardesty is a curator at the National Air and Space Museum and a specialist in the history of Russian aviation. He has written a biography of Charles Lindbergh and, most recently, *Air Force One: The Aircraft That Shaped the Modern Presidency* (Northword Press, 2003).

Comet Cracker. Consulting editor Tony Reichhardt wrote "Contact," an article about the early days of aerial exploration, in the Oct./Nov. 2004 issue of *Air & Space.*

Red Bull's Rodeo. Larry Lowe is a former competition aerobatic pilot, low-level airshow pilot, and Reno race pilot.

So You Want to Be an Airshow Pilot. Phil Scott (*www.philipscott.net*) is the author of *Deadly: The World's Deadliest Everything.*

A Little Lift. Paul Ciotti is a Los Angeles-based writer who has long been attracted to the notion of low, slow, efficient flight.

How Things Work: The Meatball. Sam Goldberg is an associate editor at *Air & Space.*

The People and Planes of Anoka County. Longtime contributor Carl Posey's affinity for Minnesota began at the Breck School in St. Paul, where his father was a district airport engineer for the Civil Aeronautics Administration.

Frequent contributor and aviation photographer Erik Hildebrandt is working on a fifth coffee-table book of photographs, this one on the Grumman F-14 Tomcat; the book is to be released in spring 2006 to coincide with the last carrier deployment of the legendary U.S. Navy fighter.

CALENDAR

April 1—July 5
Wings of Freedom Air Tour. Sponsored by the Collings Foundation. Restored B-17 and B-24 bombers will make stops in 39 U.S. cities; to view schedule, visit *www.collingsfoundation.org,* (800) 568-8924.

April 2
Seminar on Air Power Over Southeast Asia. The event will conclude with a flight demonstration of a Vietnam-era combat aircraft. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org.*

April 7—9
AeroExpo 2005. Santa Fe Convention Center, Mexico City, Mexico, phone 52 55 55 64 99 31, *www.aeroexpo.com.mx.*

April 9
New England Aviation Expo. Featuring exhibits, classes, and workshops on safety issues for general aviation pilots and aircraft technicians. Eaton-Richmond Center, Daniel Webster College, Nashua, NH, (603) 879-6807, *www.faa.gov/region/ane/expo.*

April 18 & 19
World Regional Airports Congress. Renaissance Hotel, Amsterdam, the Netherlands, phone 44 0 20 7827 4168, *www.regionalairportsworld.com.*

April 28—30
Whirly-Girls International 50th Anniversary Celebration. Washington, DC, (206) 250-3209.

May 21 & 22
Planes of Fame Airshow. Chino Airport, CA, (909) 597-3722, *www.planesoffame.org.*

May 26—28
Reunion: All U-2 and RB-57D squadrons of the 4080th Strategic Reconnaissance Wing. Civic Center, Del Rio, TX, (830) 775-5346.

May 27—29
Watsonville Fly-In and Airshow. Watsonville Municipal Airport, CA, (831) 763-5600, *www.watsonvilleflyin.org.*

Organizations wishing to have events published in Calendar should fax press releases to (202) 275-1886; e-mail them to editors@airspacemag.si.edu; *or mail them to Calendar,* Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

FORECAST

In the Wings...

NASM (SI NEG. #88-10696)

Heaviest single-engine fighter of World War II: Republic's P-47.

The Jug and the Greatest Generation
How regular guys became supermen who fought winter and war to keep P-47 Thunderbolts flying.

Zoom Zoom
You may not know that NASA's scramjet-powered X-43 nudged up against Mach 10 last fall. There was little fanfare, but here's why it was a big deal.

Drop-Dead Gorgeous
In the case of the T-38 Talon, pilots agree that beauty is more than skin deep.

The People and Planes of Creve Coeur
Wacos rule at Creve Coeur Airport, just down the road from the mighty Mississippi, where small-town America is alive and flying. (Stearmans run a close second.)

Nike: Winged Controversy
At first, the missile emplacements that encircled American cities in the 1950s made everyone feel safe. In the end, they made everyone mad.

Leroy's Launch
The most interesting part of a U.S. astronaut's journey to the space station could be the leg through Russia and Kazahkstan.

ON THE WEB SITE

www.airspacemag.com

Look for extended coverage of the Red Bull Air Race and find out how to fly Red Bull Copilot, a race simulator.

You'll also find more photographs of the airplanes promoted and exploited by the regimes of Hitler, Mussolini, and Stalin.

Use the Web site to renew your subscription, buy gift subscriptions, or send us fan mail!

DIANA PAGE/THE LIGHTSHIP GROUP

The Saturn Relay Lightship at the end of its tether.

A Lot More Than Helium

Blimps are a staple of many major sporting events in the United States. Whenever there's a big game, an airship, more popularly called a blimp, is sure to be floating serenely overhead with an advertiser's name splashed across its side.

But when the Saturn Relay Lightship took flight on September 14, 2004, it was doing more than advertising its sponsor—it was pursuing a spot in the aviation record books while demonstrating its capabilities as a law enforcement aid. Pilot Carl Harbuck and copilot Douglas McFadden established a new record for duration aloft for six sub-classes—based on volume—of gas airships without a rigid framework, setting a new mark of 24 hours, 39 minutes, and 55 seconds. (If a pilot sets a mark at a lower volume, he can also claim the records for higher-volume blimps if his record beats the established marks for those blimps too.)

"We wanted to bring attention to airships and what they can do from a security standpoint," says Harbuck, who has flown over many big events, from the World Series to the Super Bowl. "You obviously get a great view of things, and it's good for long-term surveillance."

Proving the "long-term" part is what inspired the pilots' duration record attempt. Harbuck, who has been an airship pilot for seven years, worked with law enforcement agencies occasionally prior to the attacks of September 11, 2001. Since then, Harbuck says, it has become common for law enforcement officials to ride along on blimps to conduct aerial surveillance: He has assisted different authorities on more than 40 occasions in the past few years.

In the 19th century, airships were built with private funds. Eventually, militaries began to see their benefit as eyes in the sky. However, the development of heavier-than-air flight at the start of the 20th century eclipsed airships…until today.

Harbuck and McFadden got their chance to make aviation history thanks to cooperation among a number of groups—the American Blimp Corporation, the lightship's manufacturer; the Lightship Group, the lightship's operating company; and automaker Saturn Corporation, the lightship's sponsor. By going after the old record of 14 hours and nine minutes, set in 1998, and beating it so handily, they clearly demonstrated a blimp's ability to stay aloft for lengthy, uninterrupted periods.

Harbuck guesses that under optimal conditions, the lightship could have stayed up for more than 30 hours. But he's happy with the standard he set. "Other airships can fly that long," Harbuck says. "But to put our record out there—it'll be a challenge to break it."

And while flying a blimp may seem easy to the untrained observer, a lot more than helium goes into keeping an airship airborne for that long. Harbuck, McFadden, and the others involved with the flight had to take into account takeoff weight, fuel consumption and mixture, the amount of helium to be released during the flight, and the weather: The sun's heat has a significant effect on the airship's performance.

"It took a lot of planning," Harbuck says. "You have to make a lot of calculations on the ground and adjustments in the air. Everything went like we planned. It was a beautiful flight."

—Dustin Gouker

LOGBOOK

The Collier Trophy

The Robert J. Collier Trophy is one of the oldest and most prestigious awards in aviation. Collier was elected president of the National Aeronautic Association in 1911. One of his goals was to show the general public that the airplane was a safe vehicle, and indispensable to the world's future. He came up with the idea of a trophy—originally called the Aero Club of America Trophy—that would be awarded "for the greatest achievement in aviation in America, the actual value of which has been thoroughly demonstrated by use the preceding year."

The Collier Trophy is presented by the president of the United States—a tradition that demonstrates its importance to aviation in this country. The list of past winners reads like a Who's Who of aviation history, and provides a timeline of aeronautic achievements: Glenn Curtiss won the first two Collier Trophies for his development of "hydro-aeroplanes," while Orville Wright won the third trophy for developing an automatic stabilizer.

In 1938, Howard Hughes won the award for completing a flight around the world in 91 hours and 14 minutes. Chuck Yeager and Bell Aircraft earned the Collier in 1947, when Yeager famously flew the Bell X-1 faster than the speed of sound. In 1962, U.S. astronauts were recognized for pioneering spaceflight, and the Apollo 11 astronauts accepted the trophy in 1969 for landing on the moon.

This year's Collier Trophy winner, the SpaceShipOne team, joins an elite group of U.S. aviation pioneers. SpaceShipOne's achievements will be detailed in the next issue of *Air & Space/Smithsonian.*

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*